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STUDIES IN INHERITANCE OF CERTAIN CHARACTERS OF CROSSES BETWEEN DAIRY AND BEEF BREEDS OF CATTLE [1]

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INTRODUCTION

An outstanding need of present-day genetics is the analysis of the hereditary variations in the economically important domestic animals. It is the purpose of this paper to present a preliminary analysis of the data from the first-generation crosses of the prominent dairy breeds of cattle on the beef breed Aberdeen-Angus (*22, 42*).[2]

This work has been undertaken as a link in the chain of evidence necessary to the final solution of the problems which are connected with the inheritance of milk and butter-fat production. Considerable work has already been done in this laboratory in the analysis of the variation in these characters without immediate regard to the inheritance of such variation (*27–38*). These studies, it is believed, lay the foundation for the accurate analysis of such characters, for without a comprehensive understanding of the normal fluctuation of such quantitative character as milk production, it is practically impossible to determine such inheritance.

Further, the only method now known by which an adequate analysis of these laws of hereditary can be made is by hybridization experiments so carefully planned that the segregating factors may be analyzed separately. To that end a crossbred herd is being formed to accumulate as much material as possible for the analysis of such hereditary variation. This crossbred herd has now gone into its second generation. It seems wise, therefore, to make a preliminary analysis of the data of the first-generation herd.

This paper will have as its object the analysis of the inheritance of the more prominent characters of the first generation of this crossbred herd.

The plan of the work and its early prosecution was carried on by Dr. Raymond Pearl. Through the exigencies of the war the analyses of the data so far collected and the further prosecution of the work has fallen to the author. The results of this analysis are presented in the

[1] Reference is made by number (italic) to "Literature cited," p. 54–57.

[2] Papers from the Biological Laboratory of the Maine Agricultural Experiment Station, No. 120.

following pages. The conclusions drawn from them are the author's, and he is alone responsible for them.

FOUNDATION HERD

The stock available for the crosses consisted of the following breeds in the relative proportions shown in Table I: Holstein-Friesian, Guernsey, Jersey, Ayrshire, and Aberdeen-Angus.

TABLE I.—*Breeds available as foundation stock for the crossbred herd*

Breed.	Male.	Female.
Holstein-Friesian	2	3
Holstein-Friesian grades		37
Guernsey	2	16
Jerseys	1	10
Maine State Jerseys		6
Maine State grades		1
Ayrshire	1	8
Angus	2	5
Total, all breeds	9	86

It will be noted that there were a number of grades carrying much Holstein-Friesian blood. These were not used, since to carry convincing proof the ultimate results must be based on experiments with stock bred for some generations for the characters which were to be studied: milk, butter fat, and beef; otherwise the results might be explained by the heterogenous mixture of factors contained in the grades. The stock, together with the breeds which were finally used in the foundation crosses, is shown in Table II. They are all animals of good breeding and come from lines productive in milk, butter fat, or beef production, as the case may be.

It seems well at this point to consider the qualities of this foundation herd in respect to its inbreeding and possibilities of increased vigor due to heterosis of the crossbred progeny. Studies of the known inbreeding of this foundation herd have been made. The choice of a definite numerical measure of this inbreeding is necessary to any adequate study. Several such figures have been given to the students of inbreeding through studies of this laboratory (*27–38*). It is thought wise to use only one of these measures—namely, the coefficient of inbreeding—as this measures the total amount of inbreeding which has taken place in the pedigree of a given animal. Table III gives this amount of inbreeding in the successive generations, up to the fourth, known to have taken place in the pedigree of the animals used in this foundation herd. It will be noted that these inbreeding coefficients are, in general, low, compared with those of the animals already studied in this laboratory. This indicates that inbreeding would have little effect in increasing the vigor or production by the animals of the crossbred herd.

TABLE II.—*Parents of the crossbred herd*

Breed and animal.	Times bred.	Breed and animal.	Times bred.
JERSEY:		GUERNSEY:	
Lakeland's Poet (102603)	6	Lady Primrose's Governor of the Fountain (18328)	1
Columbia's Fox (126386)	1	Canada's Cresua (44386)	2
Flora's Golden Poetess (264927)	2	College Creusa (25661)	3
Rosalie (MSJHB 4887)	3	Creusa of Orono 3d (34228)	2
Ruth 8th (MSJHB 4457)	(a)	College Gem (40037)	1
Flying Fox's Flora (274051)	2	College Creusa 2nd (34227)	2
College Ruth (MSJHB 4895)	1	Creusa's Lady (53234)	1
Rue Victoria (273096)	2	College Gem 2nd (53235)	1
Columbia Brown Bessie (148551)	1	AYRSHIRE:	
Lassie of M. F. (297736)	1	Dot Alaska (20353)	3
HOLSTEIN-FRIESIAN:		Maple Grove Netta (29307)	2
Delva's University De Kol (146774)	1	Orono Netta (38832)	1
Johanna Lad Manor De Kol (41913)	1	ABERDEEN-ANGUS:	
Taurus Creamelle Hengerveld (98482)	16	Kayan (167617)	21
Pauline Posch (81048)	4	Eventime 4th (155526)	3
Delva Johanna De Kol (33910)	2	Hearthbloom (147141)	3
		Orono Madge (192781)	2
		Orono Ellen (192783)	2

(a) Twins once.

TABLE III.—*Amount of known inbreeding in the foundation herd*

Name of animal.	Known repeated ancestors' generations.				Total known repeated ancestors for four generations.	Coefficient of inbreeding.
	1	2	3	4		
Canada's Creusa (44386)	.....	.....	2	.....	4	25.000
College Creusa (25661)	.....	.....	2	.....	4	25.000
College Creusa 2nd (34227)	.....	.....	.....	2	2	12.500
College Gem (40037)	.....	.....	.....	.....	0	.000
Columbia's Brown Bessie (148551)	.....	.....	.....	1	1	6.250
Columbia's Fox (126386)	.....	.....	.....	.....	0	.000
Creusa's Lady (53234)	.....	.....	.....	.....	0	.000
Creusa of Orono 3rd (34228)	.....	.....	.....	2	2	12.500
Delva Johanna De Kol (146774)	.....	.....	.....	1	1	6.250
Delva's University De Kol (133910)	.....	1	.....	.....	4	25.000
Eventime 4th (155526)	.....	.....	.....	1	1	6.250
Kayan (167617)	.....	.....	.....	1	1	6.250
Hearthbloom (147141)	.....	.....	.....	.....	0	.000
Flora's Golden Poetess (264927)	.....	.....	1	1	3	18.750
Flying Fox's Flora (274051)	.....	.....	.....	.....	0	.000
Lady Primrose's Governor of the Fountain (18328)	.....	.....	.....	1	1	6.250
Lakeland's Poet (102603)	.....	.....	.....	3	3	18.750
Lassie of M. F. (297736)	.....	.....	1	.....	2	12.500
Pauline Posch (81048)	.....	.....	.....	.....	0	.000
Johanna Lad Manor De Kol (41913)	.....	.....	1	.....	2	12.500
Rosalie (MSJHB 4887)	.....	.....	.....	.....	0	.000
Rue Victoria (273096)	.....	.....	.....	2	2	12.500
Ruth 8th (MSJHB 4457)	.....	.....	.....	.....	0	.000
Taurus Creamelle Hengerveld (98482)	.....	.....	1	1	3	18.750
Maple Grove Netta (29307)	.....	.....	.....	.....	0	.000
Average inbreeding	.....	.....	.....	.....	.....	8.654

[a] All animals that can not be traced fairly completely for the four generations are excluded from this table.

GENERAL PLAN OF THE MATINGS

The experiments for the study of the inherited characters of the different breeds were intended to include those breeds where careful selection of these characters had been made. Before passing to a study of these characters in the F_1 hybrids it seems necessary to have clearly in mind the characters of the breeds used as parents so that a definite conception of the breed and type differences may be had. Toward this end Table IV has been drawn up in the simplest form possible.

TABLE IV.—*Contrasting characters of the parental breeds of the crossbred herd*

Character.	Jersey.	Guernsey.	Ayrshire.	Holstein-Friesian.	Aberdeen-Angus.
Body color	Fawn or dun	Light fawn or dun.	Red	Black	Black.
White markings.	Often absent	Present	Present	Present	Often absent.
Switch color	Black or white.	Light fawn or white.	Red or white	Black or white.	Black.
Muzzle pigment.	Black	White	Black	do	Do.
Tongue pigment.	do	do	do	do	Do.
Horns	Horns	Horns	Horns	Horns	Polled.
Conformation	Dairy	Dairy	Dairy	Dairy	Beef.
Milk quantity	Medium	Medium	Medium	Large	Low.
Milk quality	High	High	do	Low	High.

By comparing the various characters which the different breeds exhibit, as seen in Table IV, the following character differences are brought out. The coat variations offer a range of color from black to almost white. This white is divided into more or less definitely centralized white areas, each one of which presumably behaves distinctly. The tongue colors of the Jersey and Guernsey are such that colors from white to black are available. The typical conformation of each breed is distinct, offering many points of difference. Further differences which seem rather too obvious to describe are horns, secretions, skin texture, general body build, mammary development, temperament, and the physical and chemical character of the milk. In all it is believed that the choice of the foundation stock has been almost ideal, for in each breed chosen there has been years of selection for some of the above-mentioned characters whose inheritance is to be studied.

In this connection it may be objected that the inheritance of these characters are not economically important. This is in a sense true; yet the intimate association which exists between the hereditary units necessitates the studying such things as coat color and tongue color for the full analyses of the economically important problems. It is the purpose of this preliminary paper on the first generation hybrids to lay the foundation for acquiring exact knowledge of such things as milk and beef production.

CROSSBRED HERD

TIME OF BEGINNING MATINGS

The crosses herein described are the result of matings since the spring of 1913. For the number of animals there were to work with this is satisfactory progress, and it is expected that with reasonable success the first-generation crosses will soon be complete.

PLAN OF MATINGS

The plan calls for reciprocal matings of all of the important dairy and beef characters. At first there were some crosses made which were later found to be hampered by the fact that it was impossible to keep the bulls necessary for the F_2 generation. Consequently only the heifers were saved for future breeding purposes. The breeds chosen for the foundation of the F_1 Mendelian herd were Jersey, Holstein-Friesian, and Aberdeen-Angus. The ultimate choice of these rests on the fact that these breeds have all the outstanding characters which were desired for analyses, such as low and high milk production, low and high percentage of fat, poor and good beef qualities. Besides these, the minor characters of color, secretions, and conformation offer considerable range of variability for analyses in conjunction with the analyses of the economic characters. In handling the Mendelian herd and its parential generation, it is the plan to have them under as nearly the same conditions as the rest of the herd animals as it is possible. They are raised side by side with the other herd animals and treated in exactly the same way, by the same herdsman. In the breeding of the animals a rack is used wherever there is a marked difference in size or where it is desirable to facilitate the matings. After the mating has taken place, the herdsman fills out one of the service record blanks shown in figure 1.

If the first service fails, another service is given at the next period of heat. Each of these service blanks are filled out and carefully filed. When a birth takes place, the herdsman files another blank recording such birth. The corresponding service and birth blanks are then filed together. Each animal is tagged at birth with a number corresponding with that on its birth blank. These tags are the common metal tags put through the cartilage of the ear. Besides this, when the animals are old enough, they are branded on the shoulder with their distinguishing number. Any chance in mistake of pedigree of these animals is thus reduced to a minimum.

All of the animals are kept until they are 200 days old, when they are measured for the study of conformation in relation to milk production. Besides this description the animals are carefully examined and a description of the color and other outstanding features made. Photographs of all of the animals are taken before they are sold and kept in the permanent files of the Biological Laboratory for reference.

DESCRIPTION OF MATINGS

Before passing to the analyses of the individual F_1 hybrids it is well to have clearly what each individual mating was and what differences between them could be expected. To this end Table V has been drawn up to show the matings which produced each crossbred.

FIG. 1.—SERVICE AND BIRTH RECORDS USED AT MAINE EXPERIMENT STATION.

Service record blanks are filed numerically with the herdsman. When a service is made, the service record blank is filled out immediately and filed by the author. The resulting birth is described on the birth record. The corresponding service and birth records are connected in the office.

MAINE AGRICULTURAL EXPERIMENT STATION, ORONO, MAINE

THIS INFORMATION WILL BE HELD STRICTLY CONFIDENTIAL

This blank should be filled out immediately after the service is completed, and mailed in an addressed envelope furnished you, to the Agricultural Experiment Station, Orono, Maine.

SERVICE RECORD

Date. Hour of service This record made by

BULL used. (Name.) Breed.

Is the bull registered? If so, give reg. No.

Owner of bull—Name. Address.

Age of bull. No. of coverings at this service.

COW served. (Name.) Breed.

Is this cow registered? If so, give reg. No.

Owner of cow—Name. Address.

Age of cow. When did she calve last? (Give month, day and year.)

How many times has she been in heat since calving INCLUDING this heat?

GIVE THE HOUR (AND DAY) WHEN IT WAS FIRST NOTICED THAT THE COW WAS IN HEAT BEFORE SHE WAS PUT TO THE BULL THIS TIME

How many hours had the cow been in heat before she was served?

(Do not write in this space.)

SERIES. NUMBER.

MAINE AGRICULTURAL EXPERIMENT STATION, ORONO, MAINE

THIS INFORMATION WILL BE HELD STRICTLY CONFIDENTIAL.

One of these blanks should be filled out immediately after each calf is born, EVEN IF IT IS A PREMATURE BIRTH (ABORTION). Mail to the Agricultural Experiment Station, Orono, Maine.

BREEDER'S BIRTH RECORD

Date of birth. Hour of birth. Record made by.

Was the calf male or female? (Make especial note of twin births.)

Weight of calf at birth.

Sire of calf. (Give name and breed.) Reg. No.

Dam of calf. (Give name and breed.) Reg. No.

How long was the dam dry before calving?

At what hour (and day) did labor begin?

Has the dam ever aborted? (If so give particulars)

Note any peculiarity about the birth or the calf which interests you and might interest others, especially abortions and monstrosities.

(Do not write in this space.)

Sex entered.....

Duration of gestation days hrs. (20 x)+

SERIES. NUMBER.

TABLE V.—*Number, sex, and parentage of animals of the crossbred herd*

Calf No.	Sex	Dropped.	Name of sire and registry No.	Breed of sire.	Name of dam and registry No.	Breed of dam.
		1914.				
0..	M.	Mar. 28	Lakeland's Poet (102603).	Jersey.....	Delva Johanna De Kol (146774).	Holstein-Friesian.
1..	F.	Apr. 5	.....do.....	.....do.....	Pualine Posch (81048).	Do.
2..	F.	Nov. 22	Delva's University De Kol (133910).	Holstein-Friesian..	Canada's Creusa (44386).	Guernsey.
3..	M.	Dec. 10	Johanna Lad Manor De Kol (41913).	.....do.....	Flora's Golden Poetess (264927).	Jersey.
		1915.				
4..	M.	Jan. 20	Taurus Creamelle Hengerveld (98482).	.....do.....	Rosalie (4887).....	Do.
5..	M.	Jan. 24	Kayan (167617).....	Aberdeen-Angus..	Dot Alaska (29353)..	Ayrshire.
6..	M.	Feb. 8	Taurus Creamelle Hengerveld (98482).	Holstein-Friesian.	Maple Grove Netta (29307.)	Do.
7..	M.	Feb. 13	Kayan (167617).....	Aberdeen-Angus..	Ruth 8th (4457).....	Jersey (MSJHB).
8..	M.	Mar. 23	.....do.....	.....do.....	College Creusa (25661).	Guernsey.
9..	M.	Mar. 26	.....do.....	.....do.....	Pauline Posch (81048).	Holstein-Friesian.
10..	M.	Apr. 7	.....do.....	.....do.....	Creusa of Orono 3d (34228).	Guernsey.
11..	F.	Apr. 21	Lakeland's Poet (102603).	Jersey.....	Delva Johanna De Kol (146774).	Holstein-Friesian.
12..	F.	Apr. 22	Taurus Creamelle Hengerveld (98482).	Holstein-Friesian.	College Gem (40037)	Guernsey.
13..	M.	May 4	Columbia's Fox (126386).	Jersey.....	Eventime 4th (155526).	Aberdeen-Angus.
14..	M.	June 6	Taurus Creamelle Hengerveld (98482).	Holstein-Friesian.	Flying Fox's Flora (274051).	Jersey.
15..	F.	Oct. 23	Lakeland's Poet (102603).	Jersey.....	Hearthbloom (147141).	Aberdeen-Angus.
16..	F.	Oct. 27	Kayan (167617).....	Aberdeen-Angus..	College Ruth (4895)..	Jersey (MSJHB).
17..	M.	Nov. 8	.....do.....	.....do.....	Rue Victoria (273096)	Jersey.
		1916.				
18..	M.	Jan. 1	.....do.....	.....do.....	Ruth 8th (4457).....	Jersey (MSJHB).
19..	F.	Jan. 1	.....do.....	.....do.....	.....do.....	Do.
20..	M.	Jan. 10	Taurus Creamelle Hengerveld (98482).	Holstein-Friesian.	Maple Grove Netta (29307).	Ayrshire.
21..	M.	Jan. 14	Kayan (167617).....	Aberdeen-Angus..	Dot Alaska (29353)..	Do.
22..	F.	Feb. 22	.....do.....	.....do.....	College Creusa (25661).	Guernsey.
23..	M.	Mar. 9	Taurus Creamelle Hengerveld (98482).	Holstein-Friesian.	Columbia Brown Bessie (148551).	Jersey.
24..	M.	Mar. 20	Kayan (167617)	Aberdeen-Angus..	College Creusa 2d (34227).	Guernsey.
25..	F.	Apr. 10	F_1 Crossbred (0).....	Jersey × Holstein.	F_1 Crossbred (1)....	Jersey×Holstein.
26..	F.	May 5	Kayan (167617).....	Aberdeen-Angus..	Creusa of Orono 3d (34228).	Guernsey.
27..	F.	May 25	Lakeland's Poet (102603).	Jersey.....	Orono Madge (192781).	Aberdeen-Angus.
28..	M.	June 17	Kayan (167617).....	Aberdeen-Angus...	Pauline Posch (81048).	Holstein-Friesian.
29..	F.	July 19	.....do.....	.....do.....	Creusa's Lady (53234)	Guernsey.
30..	M.	Aug. 29	Taurus Creamelle Hengerveld (98482).	Holstein-Friesian.	Orono Ellen (192783).	Aberdeen-Angus.
31..	M.	Sept. 11	Lakeland's Poet (102603).	Jersey.....	Eventime 4th (155526).	Do.
32..	M.	Sept. 25	Kayan (167617).....	Aberdeen-Angus..	Canada's Creusa (44386).	Guernsey.
33..	F.	Oct. 9	Lady Primrose's Governor of the Fountain (18328).	Guernsey.....	Hearthbloom (147141).	Aberdeen-Angus.
34..	F.	Oct. 17	F_1 Crossbred (0).....	Jersey×Holstein..	Rosalie (4887).....	Jersey (MSJHB).
35..	M.	Nov. 10	Taurus Creamelle Hengerveld (98482).	Holstein-Friesian.	Flying Fox's Flora (274051).	Jersey.
36..	M.	Dec. 15	Kayan (167617)	Aberdeen-Angus..	Orono Netta (38832).	Ayrshire.
		1917.				
37..	F.	Jan. 5	.....do.....	.....do.....	Dot Alaska (29353)..	Do.
38..	M.	Jan. 13	F_1 Crossbred (10).....	Angus×Guernsey.	College Creusa (25661).	Guernsey.
39..	M.	Jan. 28	Kayan (167617).....	Aberdeen-Angus..	Rue Victoria (273096).	Jersey.
40..	M.	Feb. 9	.....do.....	.....do.....	College Creusa 2nd (34227).	Guernsey.
41..	F.	Feb. 9	.....do.....	.....do.....	College Gem 2nd (53235).	Do.
42..	F.	Mar. 25	Crossbred 0.....	Jersey - Holstein Friesian.	Flora's Golden Poetess (264927).	Jersey.
43..	M.	Apr. 30	.....do.....	.....do.....	Crossbred 1..... ..	Jersey-Holstein-Friesian.

TABLE V.—*Number, sex, and parentage of animals of the crossbred herd*—Continued.

Calf No.	Sex	Dropped.	Namd of sire and registry No.	Breed of sire.	Name of dam and registry No.	Breed of dam.
		1917.				
44..	F.	May 4	Taurus Creamelle Hengerveld (98482).	Holstein-Friesian.	Orono Madge (192781).	Aberdeen-Angus.
45..	F.	May 13	Kayan (167617).....	Aberdeen-Angus..	Pauline Posch (81048).	Holstein-Friesian.
46..	F.	June 6	Taurus Creamelle Hengerveld (98482).	Holstein-Friesian.	Lassie of M. F. (297736).	Jersey.
47..	F.	Aug. 6	.....do.....	.....do.....	Hearthbloom (147141).	Aberdeen-Angus.
48..	M.	Aug. 10	Crossbred 0.....	Jersey - Holstein-Friesian.	Crossbred 11.....	Jersey-Holstein-Friesian.
49..	F.	Aug. 15	Taurus Creamelle Hengerveld (98482).	Holstein-Friesian.	Crossbred 2.....	Holstein-Friesian-Guernsey.
50..	M.	Aug. 22	.....do.....	.....do.....	Eventime 4th (155526).	Aberdeen-Angus.
51..	M.	Aug. 27	.....do.....	.....do.....	Crossbred 12.....	Holstein-Friesian-Guernsey.
52..	F.	Oct. 11	.....do.....	.....do.....	Orono Ellen (192783).	Aberdeen-Angus.
53..	M.	Oct. 21	.....do.....	.....do.....	Rosalie (4887).....	Jersey (MSJHB).

An examination of Table V shows that at the beginning of the experiment there was a large preponderence of males. This is shown graphically in figure 2.

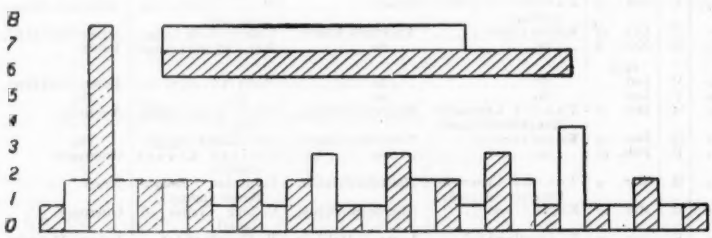

FIG. 2.—Diagram showing graphically the number and sex sequence of the births composing the crossbred herd. The clear rectangles are female. The cross-hatched rectangles are the male.

This preponderance of males is shown by figure 2 to be due to a large excess of males in the first matings. In view of the fact that there is probably no relation between the time of service and the sex of the animals produced, this excess is to be explained on the basis of chance. Unfortunately, this first excess of males in the birth has not been completely neutralized, but still leaves a good number of males over the expected half. In the first 54 births there were 31 males to 23 females. Since the segregation of the sex-determining elements probably takes place in the male, it is interesting to see what is the relation between the individual bulls in regard to the sex of the offspring produced. The numbers as yet are rather too small to draw any definite conclusion, but are still large enough to be of interest. Table VI gives such a comparison of breeds.

TABLE VI.—*Relation of the sex produced to breed of bull*

Breed and name.	Male.	Female.
JERSEY:		
Lakeland's Poet	2	4
Columbia Fox	1	.....
Total	3	4
HOLSTEIN:		
Delva's University De Kol	.....	1
Johanna Lad Manor De Kol	1	.....
Taurus Creamelle Hengerveld	10	6
Total	11	7
ABERDEEN-ANGUS:		
Kayan	15	8
Total	15	8
GUERNSEY:		
Lady Primrose's Governor of the Fountain	.....	1
Total	.....	1
CROSSBRED:		
No	2	3
Total	2	3
Grand total	31	23

Table VI shows that the large number of males is principally due to two animals—Taurus Creamelle Hengerveld and Kayan. This increased number over half does not belong to any breed difference, but is probably simply a function of chance sorting.

DESCRIPTION OF THE PARENTAL HERD

The description of the parents and their crossbred offspring will be arranged in the following form in order to facilitate comparison. The description of the individual parents will be made first.

The description of the animals will be given in the following form: First, the sex, then the color and markings of the various parts of the body—muzzle, tongue, switch, horns, hoofs, and secretions—and then the general type that the offspring exhibits in regard to its breed characteristics. The further points considered will be in the following succession: Type as judged by dairy or beef production, number and placement of teats or rudimentaries, description of milk veins and wells, and lastly the capacity and quality of the udder.

The individual descriptions of the crossbred animals follow that of their parents. The mating is given first, then the number of the resulting offspring. The rest of the description of these crossbreds follows the same form as that of their parents.

DESCRIPTIONS OF ANIMALS IN PARENTAL HERD

Aberdeen-Angus Herd

Male: Kayan (167617).—Solid black except for a small amount of white around rudimentaries. Muzzle black; tongue slate; switch black, with a few gray hairs scattered through it. No horns nor traces of them. Hoofs black, and secretions dark brown. The head is a good typical Aberdeen-Angus head. Well-rounded low-set bull, kept in rather low flesh for breeding purposes. Four rudimentaries; milk veins fairly large and long.

Female: Eventime 4th (155526).—Solid black; muzzle black; tongue slate; switch black, with a few gray hairs in it. No trace of horns present. Hoofs black; secretions dark brown. The face is typically Angus. The shoulders, barrel, rump, fore and hind quarters are not deeply fleshed and lack the filling typical of Angus. In short, the cow has some traces of the dairy type; at the same time she has the deep, blocky body characteristic of the beef breed. Four fair teats and two rudimentaries. Fair-sized milk veins and wells. Udder large for such a low-milking breed (Pl. 1, A).

Female: Hearthbloom (147141).—Solid black except for a few white hairs between the fore teats. Muzzle black; tongue black. Switch black, with a few gray hairs in it. No trace of horns or scurs. Hoofs black; secretions dark brown. Typical Aberdeen-Angus in shoulders, head, barrel, and fore and hind quarters of an animal in breeding condition. Four well-placed teats, udder of small capacity. Milk veins and wells small. A typical beef cow having none of the dairy points developed to any extent (Pl. 1, B).

Female: Orono Madge (192781).—Black except for a small white area on the teats. Muzzle and tongue black; switch black, with a few gray hairs in it. Horns entirely absent. Hoofs black; secretions dark brown. Face rather lacking somewhat in the Aberdeen-Angus type. It is rather too thin. Body lacks filling in chine and over the withers. Four teats and one rudimentary. Milk veins and wells are small. Udder of low capacity.

Female: Orono Ellen (192783).—Solid black except for a few white hairs on hind quarters of udder. Muzzle black; tongue black; switch black. No trace of horns; hoofs black. Secretions dark brown. A typical Aberdeen-Angus cow in low flesh. Four teats and one rudimentary on right side between the fore and hind teats. Udder of low capacity and meaty in texture.

Ayrshire Herd

Female: Dot Alaska (29353).—Red, white, and black; black confined to outside of nostrils. Majority of the body is dark red. Spotting irregular in area, occurring on the shoulders, brisket, belly, flank, rump, and base of tail. Practically all of the white areas are flecked with the red islands. Muzzle black; tongue white; switch red and black, mixed with some gray. Horns are not at all "typy" of the Ayrshire, as they are too thin and not thrown upward sufficiently. Hoofs black; secretions orange. Face has too much dish and the body is too short and too low to the ground for the good type of Ayrshire animal. Udder rather small and only of fair shape. Milk veins and wells of medium length and size. The animal is much too small and light, even for the New England type, the type she most resembles.

Female: Orono Netta (38832).—Red and white; large broad star. Shoulders and brisket and front part of fore and hind legs white. The barrel and rump are white-spotted, each spot containing large irregular islands. Muzzle black; tongue black. White, heavy horns, pretty well up. Hoofs black; secretions small in amount and yellow. Dark-red nose, with a few gray hairs scattered through it. Rump not quite as level as would be expected of an animal typical of the breed. Hind quarters somewhat heavy. Udder small, especially in the fore quarters. Milk veins and wells small. Four well-placed teats (Pl. 1, C).

FEMALE: MAPLE GROVE NETTA (29307).—Color red and white. Much resembling the spotting of her daughter, Orono Netta. Muzzle black; horns heavy; black-tipped and thrown forward and up, as would be characteristic of the Ayrshire. Udder good-sized and well shaped. Well carried out in fore quarters. General type is that of the New England Ayrshire.

GUERNSEY HERD

MALE: LADY PRIMROSE'S GOVERNOR OF THE FOUNTAIN (18328).—Color a light yellow and white. White confined chiefly to the shoulders, legs, and belly. Muzzle is flesh-colored. Switch white. Horns coming out at right angles to head and curving slightly forward. Good Guernsey form both in head and in fore and hind quarters. Four well-developed rudimentaries (Pl. 2, A).

FEMALE: COLLEGE GEM (40037).—Color orange and white. White on belly, fore and hind legs chiefly. Tongue white; few white hairs on face; muzzle smutty; switch white. Horns large, thrown forward, up and back, black tipped. Hoofs white; secretions orange. General appearance is heavy for a dairy cow. Face a little short; body short; withers thick, well-developed; broad girth; rump fairly short; tail set high; twist well-filled. Udder small and poorly shaped. Veins and wells fairly large.

FEMALE: COLLEGE GEM 2ND (53235).—Color: Orange and white. White star on forehead. Two white spots on left shoulder. Belly white; short white stocking on left foreleg, extending as long white area along front of leg to brisket.

Hind legs are white below the knee. Muzzle white; tongue white; switch white. Horns long and slender, thrown up and back. Hoofs white; secretions orange, large in amount. The animal exhibits a fair Guernsey type. although rather light in body weight and heavy in shoulders. Udder of fair shape; teats rather well placed; medium-sized milk veins and wells.

FEMALE: COLLEGE CREUSA (25661).—Color orange and white, white star on forehead. Muzzle has a grayish area around it. Broad band of white extending across the shoulder and connecting with the white belly. Forelegs, brisket, and udder white. Broad band of white across the rump including the exterior end of the chime and running down on forelegs as far as the hoof. Muzzle white, with a few black spots on it. Tongue white; switch white. Horns heavy, thrown up and back. Hoofs white; secretions orange. The general type is that of a fair Guernsey. Udder is good size, although rather poor in shape. Milk veins and wells good size.

FEMALE: COLLEGE CREUSA 2ND (34227).—Color orange and white. Large white star. Udder white, broad band extending over rump to fore sides of white hindlegs; hindlegs are clear white to knee. Muzzle white; tongue white; switch white. Horns long, thin, thrown upward and curved forward and in. Hoofs white; secretions orange, large in amount. Nose narrow, strong, good dish and veins. General type is that of a fair Guernsey. Udder rather small, pendant, and poorly shaped. Medium-sized veins and wells.

FEMALE: CREUSA'S LADY (53234).—Color yellow and white. Star, white spot on both shoulders, extending over withers. Belly white; forelegs white on the inside; short stockings. White spot on left side of barrel. Rump and tail set white. Irregular white lines in front of hindlegs, extending down into clear white area below the knee. Muzzle, tongue, and switch white. Horns thrown forward and up. Hoofs white; secretions orange. Animal is rather light in weight and withers are a trifle heavy for a typical Guernsey animal. Milk veins lead to rather good wells (Pl. 2, B).

HOLSTEIN-FRIESIAN HERD

MALE: JOHANNA LAD MANOR DE KOL (41913).—Color black and white. Star. Broad band of white just back of the shoulders, extending around the body. Forelegs white, tail set white, hindlegs white, the white extending as irregular area upwards to the flank. Muzzle black, switch white. Horns large and thick, coming

out at right angles from head. Good Holstein-Friesian type; if anything the head has too much of the aquiline and perhaps might be considered chunky. Neck and shoulders are heavy. Crest is large. Rump well rounded. Throughout, the bull gives the appearance of a strong, masculine development.

MALE: TAURUS CREAMELLE HENGEVELD (98482).—Color black and white. White on face, shoulders, and belly. Stockings on fore and hind feet. Muzzle black; tongue and switch white. Large straight horns come out at right angles from head. Hoofs white, with black streaks in front; secretions dark brown. Four well-placed rudimentaries. Veins long, leading to good-sized wells. In the white areas the skin may be seen to be spotted with black. All in all the bull is a good large type of Holstein-Friesian (Pl. 2, C).

FEMALE: PAULINE POSCH (81048).—Color black and white. Broad white blaze. Throat white. Forelegs white. Broad band of white on both shoulders and over withers. Brisket and belly white. Irregular white area running from white hindleg over the flank and across white rump to connect on the other side with a white area coming from the other hindleg. Muzzle black and white. Tongue and switch white. Horns fairly heavy, curving forward and down. Hoofs black-and-white streaked; secretions dark brown. Good Holstein-Friesian type. Udder somewhat too pendant and lacks filling in the fore quarters. Milk veins tortuous and of good size. Wells good size.

FEMALE: DELVA JOHANNA DE KOL (146774).—Color black and white. White star. Brisket and dewlap white. White forelegs. Belly and udder white. Hindlegs white, the white areas extending irregularly onto the flank. Muzzle black. Tongue and switch white. Horns fairly heavy, turning forward. Hoofs white; have a black streak in front part; secretions dark brown. Udder has a tendency to be somewhat pendant. Veins large and tortuous. Fair-sized wells. The skin under the white areas can be seen to be black.

JERSEY HERD

MALE: LAKELAND'S POET (102603).—Color black, brown, and dark fawn. Head and shoulders dark brown to black, gray at base of horns. Back a dark fawn. Legs dark fawn. Hair extremely heavy on face. Muzzle black; tongue black, with a small white spot on tip; switch black. Strong horns turned forward and in. Hoofs black; secretions yellow. Rump a trifle long. Dewlap rather prominent. Four rudimentaries fairly well placed. Small milk veins and wells (Pl. 3, A).

MALE: COLUMBIA'S FOX (126386).—Color solid except for a small white spot on right stifle. Tongue black; switch black.

FEMALE: LASSIE OF M. F. (297736).—Color gray-fawn. Black spot on forelegs just above hoofs. Hindlegs light gray-fawn. Muzzle and tongue black. Switch black, with a few gray hairs in it. Horns turned forward and in. Hoofs black; secretions yellow. Face a little long; nose a little narrow. Withers somewhat heavy and a little too prominent for a perfect Jersey type. Udder of excellent proportions and of good size. Teats well placed; milk veins on right side branched, on the left side single (Pl. 3, B).

FEMALE: ROSALIE MSJHB (4887).—Color a light cream and black. Black on front side of face, forelegs, and hind quarters. Muzzle black; tongue black; switch black. Horns black and white, rather light, thrown forward and up; hoofs black; secretions yellow. The animal is not at all a good Jersey type because of the heavy withers, pronounced dewlap and barrel showing little tendency to the typical V-shape. Udder is rather small; teats small; milk vein on right side long, left side short and small.

FEMALE: RUTH 8TH MSJHB (4457).—Color solid orange. Muzzle black; tongue black; switch black. Horns fine, white tips. Hoofs black; secretions yellow. Face is overrefined. Dewlap and brisket too much in evidence. Vertebra wide apart.

Barrel medium-sized. Long level rump; fine clean bones. Cow in extremely poor condition. Udder rather good size, pendant; teats large and long; milk veins short and of fair size.

FEMALE: COLLEGE RUTH MSJHB (4895).—Solid color, yellow fawn, varying in shades. Dark on face, neck, and back. Light on nose, belly, and legs. Muzzle black; tongue white, background covered with small black spots; switch black. Horn slendor, turning forward and up, white base, black-tipped. Hoofs black; secretions yellow. Udder small, deeply cut between quarters. Small teats; good-sized veins, rather long and leading to good-sized wells.

FEMALE: RUE VICTORIA (273096).—Color solid, a general light cream. Muzzle black; tongue black; switch black. Horns heavy, turning forward and in. Hoofs black; secretions yellow. Face and neck are fair type. Shoulders heavy; brisket of good size. Barrel short; rump long and level. Udder rather small; teats well placed; milk veins good-sized and tortuous.

FEMALE: FLYING FOX'S FLORA (274051).—Solid color. Muzzle black; tongue black; switch black. Horns black-tipped, turn forward and in. Secretions yellow. Udder good size with well-balanced quarters. Teats well placed.

FEMALE: COLUMBIA'S BROWN BESSIE (148551).—Solid color. Muzzle black; tongue black; switch black. Horns turn forward and down. Udder pendent, hind quarters good; fore quarters rather poor. This may not be the natural condition, as the animal is quite old.

FEMALE: FLORA'S GOLDEN POETESS (264927).—Solid color, dark gray-fawn. Face and front part of forelegs dark. Muzzle black; tongue black; switch brown. Horns fair-sized, curving forward and in; white at base and black-tipped. Hoofs black; secretions yellow. Udder capacious, somewhat cut between quarters. Good-sized, tortuous veins, rather short. On the whole an excellent typical Jersey animal.

INDIVIDUAL DESCRIPTIONS OF THE CROSSBRED HERD

CROSSBRED 0: Lakeland's Poet (102603) × Delva Johanna De Kol (146774)—Jersey × Holstein-Friesian.

Male: Black, small amount of white; white spot on left front; elbow joint; white on brisket; small area in inguinal region. Muzzle and switch black; tongue black, with white spot in the middle of it. General type is that of the Holstein-Friesian. Horns heavy, coming straight out from head (Holstein-Friesian type). Four rudimentaries, one supernumerary placed on the scrotum.

CROSSBRED 1: Lakeland's Poet (102603) × Pauline Posch (81048)—Jersey × Holstein-Friesian.

Female: Black and white. No white on face; white spots on left side of brisket, extending as white streaks under forelegs; white spots flecked with black on left flank, irregular white areas on right side of udder. Muzzle black and white; switch black; interspersed with a few white hairs. Horns have white base, black tips, of medium weight, curving forward and in. Hoofs black; secretions light brown. General type that of a Holstein-Friesian × Jersey intermediate. The face and horns give more the impression of the Holstein-Friesian, for there is no dish in the face, and the body lacks the wedge shape of the Jersey. The lack of fleshing and small size of barrel show the Jersey influence. Udder pendent, with four poorly placed teats. Milk veins and wells rather small. Rather a low milker with a fair percentage of butter fat. Has a quiet dairy temperament.

CROSSBRED 2: Delva's University De Kol (133910) × Canada's Creusa (44386)—Holstein-Friesian × Guernsey.

Female. Black and white. Practically all black areas have some red on the base of the hair. White strip on face; white spot on shoulder connected on left side with a white belly, which extends as far forward as the end of the brisket. Forelegs white;

teats and udder white; white on hind legs, extending as an irregular area onto the flank. Tail about half white. Muzzle black, with white spot in the middle of it. Tongue white; switch white; horns white at base, black tips, turn upward and in. Hoofs white; secretions slight and dark brown. In general, the body type is that of a Holstein-Friesian. Udder of good size, but poor in shape; lacks filling in fore quarters, tending to be somewhat pendent. Four teats, one supernumerary on left side near the fore teat. Milk veins and wells of good size. Milk production rather large in quantity, but low in percentage of fat.

CROSSBRED 3: Johanna Lad Manor De Kol (41913) × Flora's Golden Poetess (264927)—Holstein-Friesian × Jersey.

Male. Black and white; white not distinctly separated from the black areas and small in the total amount. White on brisket; white spot on belly; right flank has three white spots; small white spot at base of switch. Muzzle light slate. Tongue is white with two small patches of black on left side and tip. Switch mixed black and white, black predominating. Horns those of the Holstein-Friesian, short, and curving in and upward. The type is intermediate between the Holstein-Friesian and the Jersey. In general the animal is too light for a Holstein-Friesian of the same age. Shoulders are heavy, fairly deep. Barrel is of medium size; rump long and level. Rudimentaries four and well placed.

CROSSBRED 4: Taurus Creamelle Hengerveld (98482) × Rosalie MSJHB (4457)—Holstein-Friesian × Jersey.

Male. Solid black, muzzle slate color, tongue a clay-blue, switch black. Horns of medium length, curving slightly forward. Type that of an intermediate, but giving more the impression of the Jersey than the Holstein-Friesian. This impression may be due to the evident quality and refinement which the animal exhibits. The size of bone is greater than that which may be expected of a Jersey bull of the same age, showing that, even in the question of quality, the Holstein-Friesian has had some influence. Four rudimentaries fairly well placed.

CROSSBRED 5: Kayan (167617) × Dot Alaska (29353)—Aberdeen-Angus × Ayrshire.

Male. Solid black except for a few white hairs on scrotum. Muzzle light slate. Tongue and switch black. Prominent scurs. Type in general that of the Aberdeen-Angus, although in the lateral view of the head, the straight nose, and large refined nostrils exhibit the Ayrshire character distinctly. Rudimentaries four and well placed.

CROSSBRED 6: Taurus Creamelle Hengerveld (98482) × Maple Grove Netta (29304)—Holstein-Friesian × Ayrshire.

Male. Black and white, the area of the white large in proportion to the black. Each white area has many black islands in it. The forehead has broad, V-shaped white star on it. Muzzle has a white strip. The throat is white. Upper part of forelegs and front of lower part white; white belly, the white extending across the shoulders. White on both sides of rump. Flanks and one side of hindlegs white. Muzzle slate-colored. Tongue flesh-colored; switch mostly white, but has some black in it. Type is that of an Ayrshire. Broad forehead, straight nose, clean-cut lips which are rather long. Horns large, coming straight out from head, turning slightly up. Four rudimentaries well placed (Pl. 3, C).

CROSSBRED 7: Kayan (167617) × Ruth 8th MSJHB (4457)—Aberdeen-Angus × Jersey.

Male. Solid black except for a white spot in the inguinal region. Muzzle medium slate; tongue pale clay-blue; switch black. No horns or scurs visible, although there are slight prominences under the hair. In general the type is that of an intermediate. From the front view the breadth and dish of the forehead, blockiness of shoulders and fore quarters, and the depth of barrel indicate the Aberdeen-Angus. In the side view the head is that of the Jersey, as it shows much dish. The hind quarters are too light

and thin for the Angus, and the whole body exhibits more the dairy type than the type of the beef animal. Rudimentaries four and well placed.

CROSSBRED 8: Kayan (167617) × College Creusa (25661)—Aberdeen-Angus × Guernsey.

Male. Solid color of a dark red-brown hue. Muzzle is brownish and smoky. Tongue a light slate. No horns or scurs present.

CROSSBRED 9: Kayan (167617) × Pauline Posch (81048)—Aberdeen Angus × Holstein-Friesian.

Male. Black and white. White extends from the region of the navel to the inguinal region as a narrow band. Muzzle and tongue black. Switch black, with a few white hairs scattered through it. Small loose scurs. Hoofs black; secretions brown. The head and fore quarters have a pronounced beef type. The hind quarters are not so heavily fleshed as one would expect from a beef animal of the same age. Rudimentaries four and well placed. Milk wells small; veins about 2 feet in length and of fair size (Pl. 4, A).

CROSSBRED 10: Kayan (167617) × Creusa of Orono 3d (34228)—Aberden-Angus × Guernsey.

Male. Brownish black except for a little white in front of scrotum. Muzzle and tongue light slate; switch black. No horns. The type is that of the Aberdeen-Angus, although it is much refined. The quarters lack something of the filling of the Aberdeen-Angus bull. Rudimentaries four, one small supernumerary placed in back of the hind rudimentaries about midway between them.

CROSSBRED 11: Lakeland's Poet (102603) × Delva Johanna De Kol (146774)—Jersey × Holstein-Friesian.

Female. Black and white; small star in middle of forehead. Lower part of brisket white, extending onto upper part of foreleg. There is a spot on the left foreleg and one on the right foreleg just above the knee. Upper part of belly has irregular white spots. Right side of udder white, left side of udder has the middle portion white and back part black. White spot on right flank. Lower part of tail above switch spotted with white. Little spot of white above ankle on each hind hoof. Muzzle slate; tongue white; switch white and black about equally mixed. Horns 7 inches, sharp, black tips, curving forward and in. Hoofs black; secretions a dark brown. The general type of body is that of a rather light Holstein-Friesian. In the side view of the face the thin nose and dish show clearly the Jersey influence. Four teats, one small supernumerary placed well up on middle of hind quarters (Pl. 4, B).

CROSSBRED 12: Taurus Creamelle Hengerveld (98482) × College Gem (40037)—Holstein-Friesian × Guernsey.

Female. Black, white, and gray-fawn. White on both forelegs and stockings extending to humerus. Belly has broad strip of white extending from between the forelegs as far back as the hind quarters of the udder. Hindlegs have stockings of a gray-fawn which extend as a regular line on right front side to the white on the belly. Muzzle black; tongue white; switch white; horns curved forward and slightly upward, with black tips. Hoofs black-and-white streaked; secretions orange. The type is essentially Holstein-Friesian in appearance, although the thinness of the face and the extremely heavy shoulders and high tail set show plainly the influence of Guernsey mother. The udder is of medium size, teats four and fairly well placed. Quality fair.

CROSSBRED 13: Columbia's Fox (126386) × Eventime 4th (55526)—Jersey × Aberdeen-Angus.

Male. Black, with a small amount of white on underside of throat and in the inguinal region. Muzzle slate; tongue light clay-blue; switch black. Fair-sized scurs. The breadth and height of forehead and heavy shoulders indicate the Aberdeen-Angus. The thin, narrow nose, low heart girth and lack of body depth, hair, and evident quality resemble the Jersey. However, the evident roundness of build,

and deepness of fleshing make the general type too much that of a beef animal to favor the Jersey. Four well-placed rudimentaries.

CROSSBRED 14: Taurus Creamelle Hengerveld (98482) × Flying Fox's Flora (274051)—Holstein-Friesian × Jersey.

Male. Black and white. White between the forelegs extending as irregular spotting on either side into the inguinal region. Two white spots on right shoulder; white spot on right hip and right flank. White at base of switch. Muzzle white; tongue black; switch black-tipped white coverts. Horns white. black-tipped. Hoofs black; secretions light brown. Intermediate in type between the Holstein-Friesian and Jersey. Rudimentaries well placed; milk veins and wells small; about 20 inches on either side (Pl. 4, C).

CROSSBRED 15: Lakeland's Poet (102603) × Hearthbloom (147141)—Jersey × Aberdeen-Angus.

Female. Solid black. Muzzle black; tongue slate; switch black. Horns slight stubs just through the skin. Hoofs black; secretions a dark orange bordering on brown. Head, shoulders, and withers give the appearance of the Aberdeen-Angus except that they are somewhat reduced in size. The fleshing of the rest of the body is rather heavy, but not heavy enough for the beef type. In general it may be said that the barrel, rump, flanks, and twist are of the Jersey type, which is heavily fleshed. Four well-placed teats; milk veins and wells small. Quality good. The poll of the head has the peculiar knobbed appearance which is characteristic of the Aberdeen-Angus (Pl. 5, A).

CROSSBRED 16: Kayan (167617) × College Ruth MSJHB (4895)—Aberdeen-Angus × Jersey.

Female. Solid black. Muzzle black; tongue slate; switch black. No horns present, although there are slight loose prominences under the skin. Hoofs black; secretions dark brown. The face is intermediate in type between the Jersey and Aberdeen-Angus. In the front view of the face the great breadth of forehead and nose of the Aberdeen-Angus are not seen. In the side view the face lacks the dish of the Jersey. The general type is intermediate between the two breeds, the fore quarters favoring the beef type, the barrel, rump, and hind quarters generally indicating the Jersey type, which has a considerable amount of flesh on it. Teats four, fairly well placed.

CROSSBRED 17: Kayan (167617) × Rue Victoria (273096)—Aberdeen-Angus × Jersey.

Male. Black, except for a small amount of white in front of the inguinal region. Muzzle black; tongue black; switch black. Loose scurs about 1 inch in length. Hoofs black; secretions brown. Head, shoulders, and withers resemble those of a light Aberdeen-Angus bull. The depth and length of body and rump show the characteristics of a Jersey quite heavily fleshed. Loin has more breadth and filling than would be expected of a Jersey of the same age. Milk veins about 14 inches on each side. Rudimentaries four and fairly well placed. Quality fair.

CROSSBRED 18: Kayan (167617) × Ruth 8th MSJHB (4457)—Aberdeen-Angus × Jersey.

Male. Twin to No. 19. Black in color. Died when only a day old.

CROSSBRED 19: Kayan (167617) × Ruth 8th MSJHB (4457)—Aberdeen-Angus × Jersey.

Female. Twin to No. 18. Solid black. Muzzle, tongue, and switch black. No horns, although slight, loose concrescences can be felt through the skin. Hoofs black; secretions brown. Face, shoulders, and fore quarters resemble the Aberdeen-Angus. Hind quarters are those of the Jersey in very high condition. Hair rather coarse in quality like that of its father. Four well-placed teats; milk veins small but long, leading to four wells (Pl. 5, B).

CROSSBRED 20: Taurus Creamelle Hengerveld (98482) × Maple Grove Netta (29304)—Holstein-Friesian × Ayrshire.

Male. Black and white. Broad white star on forehead. Throat white; white band extending across shoulders onto belly on the left side. White spot on right shoulder. White on dewlap and brisket. Front side of forelegs white; back black-and-white spotted. Belly black and white, white extending as an irregular band to the region of escutcheon. Spot on right flank; irregular white area extending down onto left leg from tail. Hindlegs white on front side; backside black. Line of demarcation between white and black irregular. Muzzle black; tongue white; switch white. Horns large, rather thick at base, extending upward and in, as a characteristic of the Ayrshire type. The general type of body is that of an intermediate, tending more toward the typical Scottish Ayrshire build. However, the thickness of the shoulders and the depth of fleshing show the Holstein-Friesian blood. Four rudimentaries and two supernumeraries placed near left hind rudimentary.

CROSSBRED 21: Kayan (167617) × Dot Alaska (29353)—Aberdeen-Angus × Ayrshire.

Male. Black except for a very small area of white in the inguinal region. Muzzle dark slate; tongue black-tipped, with a small spot of black on right side; otherwise white. Switch black. Horns large and quite solidly attached. The face and body generally are those of the Aberdeen-Angus, although the horns and V-shaped appearance of the head show the stamp of the Ayrshire. Fore quarters are distinctly Aberdeen-Angus, hind quarters are a trifle high in twist, and perhaps a little light for this breed. Four large, prominent rudimentaries well placed (Pl. 6, B).

CROSSBRED 22: Kayan (167617)×College Creusa (25661)—Aberdeen-Angus× Guernsey.

Female. Black and white; white streak on belly and around udder. Muzzle black. Tongue slate; switch black. Horns are entirely absent. Hoofs black; secretions brown. The face tends more to the Guernsey than to the Aberdeen-Angus type, except that the horns are lacking. Withers and brisket heavy, barrel well rounded, poorly fleshed for the Aberdeen-Angus. On the whole, the general appearance is more that of a Guernsey, which is very low set, than it is that of the Aberdeen-Angus. Teats four, well placed; milk veins and wells small. Veins are too fine for them to be felt through the thick coat.

CROSSBRED 23: Taurus Creamelle Hengerveld (98482)×Columbia Brown Bessie (148551)—Holstein-Friesan×Jersey.

Male. Black and white. White spot on forehead; white on brisket; white in inguinal region; and white stockings on hind feet. Muzzle black; tongue white, with a small black spot on tip of it. Switch white. Horns well developed, curving forward and slightly up. The general type is that of an intermediate, favoring the Jersey in the side view of the head and light-fleshed hind quarters. The shoulders and withers are those of the beef breed, although not carrying quite as much fleshing. Rudimentaries four and well placed (Pl. 5, C).

CROSSBRED 24: Kayan (167617)×College Creusa 2nd (34227)—Aberdeen-Angus× Guernsey.

Male. Black, except for white shield in inguinal region. Muzzle dark slate; tongue dark slate; switch black. Horns small and easily movable, showing that they are not attached to the bone of the head. The contour of the face is intermediate, but favors that of the Aberdeen-Angus. The body is more Guernsey than Aberdeen-Angus in type, although the heavy fleshing of the fore quarters and shoulders and rather deep flesh of the hind quarters show the beef type. The rudimentaries are four, the two front ones being quite small. All four are rather well placed.

CROSSBRED 25: Crossbred 0×Crossbred 1—Jersey-Holstein-Friesian × Jersey-Holstein-Friesian.

Female. Color black and white. Broad white star on forehead; white at throat, irregular broad white band extends over withers from the right side and connects with the belly on the left side. Brisket white; left foreleg has white stocking, and the other side is white. Belly white as far as the escutcheon. Hindlegs white. Irregular white spot including the rump and tail base. The lower extremity of the tail white. Muzzle black; tongue flesh-colored; switch white. Horns curved forward and in, rather light, and about 5 inches long. Hoofs black; secretions brown. The animal is, on the whole, rather small for her age. She exhibits the Holstein-Friesian type in the face when viewed from front or side. Shoulders and chest rather heavy and deep. Four fair-sized, well-placed teats.

CROSSBRED 26: Kayan (167617)×Creusa of Orono 3d (34228)—Aberdeen-Angus× Guernsey.

Female. Color solid black, except for a small white area around the teats. Muzzle black; tongue slate; switch black. No horns nor scurs present. Hoofs black; secretions yellow. In general, the face and shoulders favor the Aberdeen-Angus type. The barrel and hind quarters, which are quite heavily fleshed, show plainly the Guernsey character. The back is somewhat swayed, like the back of the Guernsey mother. Teats medium-sized, not especially well placed.

CROSSBRED 27: Lakeland's Poet (102603)×Orono Madge (192781—Jersey×Aberdeen-Angus.

Female. Black, with a small amount of white around the teats. Muzzle black; tongue slate; switch black. No trace of horns nor scurs present. Hoofs black; secretions yellow. The type of the face is intermediate, although rather favoring the Jersey, even while it still retains some of the breadth and lacks the dish characteristic of this breed. Shoulders are heavy and deeply fleshed. Barrel and rump give the appearance of a Jersey animal in high condition. Back is considerably swayed, this characteristic coming probably from the Jersey father. Teats four, of medium size, and rather well placed.

CROSSBRED 28: Kayan (167617)×Pauline Posch (81048)—Aberdeen-Angus× Holstein-Friesian.

Male. Black, except for a small white spot on sheath and scrotum. Very little white area on right hind leg. Muzzle black; tongue black on distal half, proximal half white; switch white. The horns are represented by small scurs shown not to be attached to the bone of the head, since they are movable. Face and fore quarters show the Aberdeen-Angus characters plainly. Hind quarters are intermediate, but favor the Holstein-Friesian, as the animal stands too high on its feet and is too highly cut up in the twist for a good Aberdeen-Angus. Four rudimentaries are present, the front ones being ¾ inch long.

CROSSBRED 29: Kayan (167617) × Creusa's Lady (53234)—Aberdeen-Angus × Guernsey.

Female. Black, brown, and white. Brown ring around eyes and on inside of fore and hind leg. White line along underside of belly. Muzzle white; tongue slate in distal, flesh color in proximal portion; black switch. No horns present. Hoofs black; secretions brown. Head narrow and thin, long for the Aberdeen-Angus; only a slight dish. The shoulders are rather heavy tending more toward the beef form than toward the dairy type. Body and hind quarters resemble the Guernsey. Four teats fairly well placed.

CROSSBRED 30: Taurus Creamelle Hengerveld (98482) × Orono Ellen (192783)—Holstein-Friesian × Aberdeen-Augus.

Male. Black and white. White extending as a line on the belly as far as the brisket. Coronets of both hind feet white. Muzzle black; tongue black; switch black and white, black predominating. Loose scurs about 1 inch in length. Hind hoofs white; front hoofs black; secretions light brown. Lower part of the face resembles the Holstein-Friesian; upper part has the character of an Aberdeen-Angus. The type of

the rest of the body is that of an intermediate, resembling the Aberdeen-Angus in the increased amount of flesh carried by the animal. Four rudimentaries fairly well placed. Animal shows a good deal of quality.

CROSSBRED 31: Lakeland's Poet (102603) × Eventime 4th (155526).

Male. Solid black. Muzzle black; tongue black; switch black. Horns are loose. Hoofs black; secretions considerable in amount and a dark orange. Face is rather long, narrow, and more on the order of the Jersey than the Aberdeen-Angus. Shoulders rather heavily fleshed. Four fairly well placed rudimentaries. Mammary vein small. Quality is rather good.

CROSSBRED 32: Kayan (167617) × Canada's Creusa (44386)—Aberdeen-Angus × Guernsey.

Male. Black except for a small area of white around rudimentaries. Muzzle black; tongue black; switch black. Horns of good length and solid. Hoofs black; secretions light brown. The head and shoulders are essentially those of an Aberdeen-Angus thinly fleshed. The rest of the body indicates the type of a Guernsey bull of about the same age. Rudimentaries rather small, placed close together.

CROSSBRED 33: Lady Primrose Governor of the Fountain (18328) × Hearthbloom (147141)—Guernsey × Aberdeen-Angus.

Female. Solid brownish black. Muzzle slate; tongue a light slate; switch black. The front view of the face resembles the Aberdeen-Angus with the exception of having a rather small muzzle. The side view shows the influence of the Guernsey. On the whole the animal is much too blocky of form to resemble a typical Guernsey, and all in all resembles the paternal side rather than the maternal in its shape of body.

CROSSBRED 34: Crossbred 0 × Rosalie MSJHB (4887)—Jersey – Holstein-Friesian × Jersey.

Female. Red and black. Light fawn on underside of throat. Neck gives a dark-red appearance, owing to the under hair being a red and the outer hair nearly black. Barrel has a dark reddish tinge, black on front side of foreleg and red on the back side. Hindlegs a red-fawn. Muzzle black; tongue black; switch black with a few hairs in it. Horns of a medium length. Hoofs black; secretions orange. The head and body give the characteristics typical of the Jersey. Four well-placed rudimentaries of fair size.

CROSSBRED 35: Taurus Creamelle Hengerveld (98482) × Flying Fox's Flora (274251)—Holstein-Friesian × Jersey.

Male. Black and white. White on belly. Short white stockings on forelegs; hindlegs have rather long stockings. Muzzle black; tongue white; switch white. Horns rather long, solidly attached. Hoofs white; secretions a light brown. The face is that of a Jersey somewhat shortened and increased in breadth. Barrel and hind limbs are Jersey except that withers are rather heavy. Four rudimentaries.

CROSSBRED 36: Kayan (167617) × Orono Netta (38832)—Aberdeen-Angus × Ayrshire.

Male. Solid black. Muzzle black, tongue slate. The type is that of an intermediate throughout. The shoulders and body are rather more thick-set and blocky than would be expected of the Ayrshire and a little too rangy for the Aberdeen-Angus.

CROSSBRED 37: Kayan (167617) × Dot Alaska (29353)—Aberdeen-Angus × Ayrshire.

Female. Black and white, the white occurring as a white irregular patch around the teats. Muzzle black; tongue black; switch black. No trace of horns. Hoofs black; secretions dark brown. Face is an intermediate between the Ayrshire and Angus, leaning more toward the Aberdeen-Angus type. Body distinctly Ayrshire except for the shoulders, which are much too heavy for that breed. Teats good size, fairly well placed. Udder of good size, quality fair.

CROSSBRED 38: Crossbred 10 × College Creusa (25661)—Aberdeen-Angus–Guernsey × Guernsey.

Male. Solid color, a dark shade of orange, a little light on fore- and hindlegs. Muzzle is badly smutted with black; tongue is cream-colored; switch red. Secretions a light orange. Face is that of a Guernsey except for the fact that it is rather short and broad. Has some dish. Shoulders are a trifle heavy, but aside from that the animal tends toward the type which would be expected of a Guernsey bull of the same age. Rudimentaries small, fairly evenly placed (Pl. 6, A).

CROSSBRED 39: Kayan (167617)×Rue Victoria (273097)—Aberdeen-Angus×Jersey.

Male. Solid black. Muzzle black; tongue slate; switch black. Scurs are short and loose. Hoofs black; secretions brown. The face is plainly that of the Aberdeen-Angus, and the general type of body is intermediate between the two breeds. Four well-placed, good-sized rudimentaries.

CROSSBRED 40: Kayan (167617) × College Creusa 2nd (34227) — Aberdeen-Angus × Guernsey.—

Male. Black and white, white limited to a small area around the rudimentaries. Muzzle black; tongue slate; switch black. Horns consist of small stubs just through the skin. Hoofs black; secretions brown. The forehead and shoulders are more those of the Aberdeen-Angus than those of the Guernsey. A thin muzzle and rather lighter fleshing of the rest of the body give the appearance of a beef and milk animal rather than that of either the beef or dairy type. Rudimentaries four, about equal distance apart.

CROSSBRED 41: Kayan (167617) × College Gem 2nd (53235) — Aberdeen-Angus × Guernsey.

Female. Solid brownish black. Muzzle black; tongue slate; switch black. No evidence of horns, but it really died too young to determine this point. Face gives a general appearance of the Guernsey type. Fore quarters, barrel, and hind quarters intermediate.

CROSSBRED 42: Crossbred ♀ × Flora's Golden Poetess (264927) — Jersey-Holstein-Friesian×Jersey.

Female. General color a dark dun, with no white spots. The dark-colored hair intimately mingled with a smaller proportion of black hair. Muzzle black; tongue black; switch black. Horns present. Hoofs black; secretions brown. The general build of the face and general body contour tends toward the Jersey type rather than the Holstein-Friesian.

CROSSBRED 43: Crossbred ♀ × Crossbred 1 — Jersey-Holstein-Friesian × Jersey-Holstein-Friesian.

Male. Four white spots on the front side of both forelegs. White brisket; irregular white spots on belly made up of four white streaks on both sides. Muzzle black; tongue white with a black spot in it toward the base; switch black. Short horns present and hoofs black. General type of both the body and face is that of a Holstein-Friesian.

CROSSBRED 44: Taurus Creamelle Hengerveld (98482)×Orono Madge (192781)—Holstein-Friesian×Aberdeen-Angus.

Female. Solid black. Muzzle black; tongue black; switch black. Very small, loose scurs present. Hoofs black. The face is narrow and thin, without much dish, indicating the Holstein-Friesian type. The fore quarters are Aberdeen-Angus. The body and hind quarters are intermediate, favoring slightly the Aberdeen-Angus type.

CROSSBRED 45: Kayan (167617) × Pauline Posch (81048) — Aberdeen-Angus × Holstein-Friesian.

Female. Black, with a small white streak on the belly. Muzzle black; tongue, distal portion black, proximal white; switch black. Hoofs black. General type is that of an intermediate, with the face and fore quarters favoring more the Aberdeen-Angus.

CROSSBRED 46: Taurus Creamelle Hengerveld (98482) × Lassie of M. F. (297736)—Holstein-Friesian × Jersey.

Female. Black and white. White belly to brisket. Short white stockings. Lower part of tail white. Muzzle black; tongue slate in the distal portions and white in proximal; switch white. Large horns present. The face is of the extreme Jersey type, almost a complete reproduction of that of her mother. The rest of the body is intermediate between the two breeds.

CROSSBRED 47: Taurus Creamelle Hengerveld (98482) × Hearthbloom (147141) — Holstein-Friesian × Aberdeen-Angus.

Female. Black and white, with small white areas extending the length of the belly. Muzzle black; tongue black-tipped, white at base; switch white-tipped. Hoofs black; secretions dark. The general type of the body and face is that of an Abdereen-Angus.

CROSSBRED 48: Crossbred 0 × Crossbred 11 — Jersey–Holstein-Friesian × Jersey–Holstein-Friesian.

Male. Black and white. Small star on forehead. Irregular white spot on left shoulder. Irregular white areas on both fore feet. Small white spot on left hind ankle. Belly white; muzzle black; tongue white; switch white. Horns present. Hoofs black. General type is that of a Jersey.

CROSSBRED 49: Taurus Creamelle Hengerveld (98482) × Crossbred 2 — Holstein-Friesian × Holstein-Friesian–Guernsey.

Male. Black and white. White under throat and on underside of neck. Fore and hind legs white; belly white; muzzle white, with four black spots scattered over it; tongue white; switch white. General appearance is that of a Holstein-Friesian.

CROSSBRED 50: Taurus Creamelle Hengerveld (98482) × Eventime 4th (155526)— Holstein-Friesian × Aberdeen-Angus.

Male. Black and white. Large star. White spot on left shoulder and irregular white spots on both flanks. Belly white to brisket; muzzle black; tongue slate at tip, with white in proximal half; switch white. This animal died when it was too young to determine whether or not horns would be present. Hoofs black in the fore parts and white behind. The general type is that of an intermediate between the two breeds.

CROSSBRED 51: Taurus Creamelle Hengerveld (98482) × Crossbred 12—Holstein-Friesian × Guernsey–Holstein-Friesian.

Male. Black and white. Medium-sized star. White belly; fore and hind feet white; muzzle black; tongue white; switch white. Horns present. Hoofs white. The general type of the body is that of the Holstein-Friesian.

CROSSBRED 52: Taurus Creamelle Hengerveld (98482) × Orono Ellen (192783)— Holstein-Friesian × Aberdeen-Angus.

Female.—Black and white, the white limited to the inguinal region. Muzzle black; tongue black; switch black. The general type of the face aud fore quarters is that of the Aberdeen-Angus, the hind quarters resembling the Holstein-Friesian.

CROSSBRED 53: Taurus Creamelle Hengerveld (98482) × Rosalie MSJHB (4887)— Holstein-Friesian × Jersey.

Male. Solid black. Muzzle black; tongue black, with a small white spot near its base; switch black. Horns present. The general appearance of the face and body is that of the Jersey type.

SPECIFIC PROBLEMS FOR ANALYSIS

These data just presented offer perhaps the most accurate scientific material on first-generation crosses that exists for the study of many vexing questions on inheritance in cattle. Their collection is the result of a carefully planned series of experiments both to test the result of other investigations and to bring forth new data on the subject. The

descriptions of the crossbreds and their parents furnish the material for the objects for our preliminary study—

(1) To determine the inheritance of the following color characters: Body colors of the dairy cattle, red, white, yellow, fawn (in its various shades), and black; the white markings, muzzle and tongue pigment, and switch color.

(2) To determine the mode of inheritance of the polled character.

(3) To determine the inheritance of the body and breed type in the first generation.

(4) To determine whether quantity and quality of milk are characters which exhibit dominance and segregation.

EXPERIMENTAL RESULTS

INHERITANCE OF COLOR CHARACTERS

Body Color

The summary of the data for the individual description is tabulated as follows: The offspring of a given bull are given under the name of the bull. The description of the mating consists of, first, the description of the character studied in the given bull and the description of this same character in the dam. Following these parental descriptions are given the description and number of a given kind of offspring resulting from a given mating. This same scheme of tabulation of the results is used for all characters studied in the paper. The term "solid color" is used in the following sense: In speaking of the general body color of an animal it means that that animal has no white markings whatsoever. In speaking of a given part of the animal, as the face, it means that this part has no white markings, although white may occur in other places throughout the coat. The term "color" is considered to be the ground color of the body and not the white spottings. With these new definitions made clear the consideration of the data on the behavior of the coat color in inheritance for our crossbred herd may be taken up (Table VII).

Table VII shows that black body color is dominant to all other colors, red, brown, and fawn. Two interesting cases of segregation occur. The deep-orange-coated bull and the dark-fawn heifer are shown to come from matings of black F_1 parents. These cases are too few to base any definite conclusions as to the number of factors in coat-color inheritance, but what they do indicate is that there is a particular inheritance and not a blending one.

These conclusions are in line with the general experiences of those who have bred black cattle and fawn or red colored animals together. Spillman (*41*) showed that the progeny of F_1 hybrids of black on red cattle behaved in Mendelian fashion with red recessive. This conclusion was further emphasized by the crosses made of the Hereford on Aberdeen-Angus by Boyd (*10*), in which he showed that this black of

the Aberdeen-Angus was dominant. The red of the Hereford segregated out in the F_2 generation. Further, in his interesting crosses of bison on domestic cattle, Boyd (*10*) shows that the bison on almost any breed produced either black or brindle body color, indicating that here also the dark body color was dominant.

Early in the study of the inheritance of color in cattle Barrington and Pearson (*6*) collected data to show that red cattle sometimes resulted from the cross of two black Galloways. This was used by them as an argument against the Mendelian explanation. It remained for Lloyd-Jones and Evvard (*20*) on their own data and that of Youatt (*59*) to show that this was no anomaly to the Mendelian explanation, but that it was due to the grade Galloways being heterozygous for this red. In some crosses of Shorthorns on Galloways they show that in the straight F_2 generation a clean-cut segregation of 20 blacks to 6 reds was obtained.

TABLE VII.—*Behavior of the general body color in the parental and first filial generations of cattle*

Sire.	Description of mating.	Offspring.
Taurus Creamelle Hengerveld.	Black × black	7 black.
Do	Black × fawn	5 black.
Do	Black × F_1 black carrying fawn.	2 black.
Kayan	Black × black	3 black.
Do	Black × fawn	15 black.
Do	Black × red	4 black.
Lakeland's Poet	Fawn × black	6 black.
Crossbred o F_1	F_1 black carrying fawn × fawn.	1 black, 1 dark fawn, some black hairs present.
Do	F_1 black carrying fawn × F_1 black carrying fawn.	3 black.
Crossbred 10 F_1	F_1 black carrying fawn × fawn.	1 deep red-fawn.
Lady Primrose's Governor of the Fountain.	Fawn × black	1 black.
Delva's University De Kol	Black × fawn	Do.
Johanna Lad Manor De Kol	do	Do.
Columbia's Fox	Fawn × black	Do.

The F_2 generation of our crosses contains two very interesting animals as above mentioned: One, a deep-orange bull, was the result of a back-crossed black F_1 bull carrying the Guernsey color onto a Guernsey. The other was produced by a back cross of a black F_1 bull, Holstein-Friesian × Jersey, onto a dark Jersey. The coat of this heifer was very dark. The appearance of the dark-fawn and deep-orange offspring from black F_1 parents indicates that segregation of the parental coat colors does occur. The deep-orange bull is of especial interest since he shows the segregation of the Guernsey coat with the color modified. This deepening of the shade of the coat seems to be confirmatory evidence for the hypothesis advanced by Wright (*58*) that the coat color of Guernsey cattle differs from the other dun-colored breeds by a reces-

sive dilution factor for this fawn. The proof for this factor being recessive comes in the fact that the F_1 cross was a back cross of a black Guernsey F_1 bull on a Guenrsey cow. Furthermore, this factor from the nature of the cross can not be sex-linked as in the case of Wentworth's explanation of the dark shade of brown in the coat of the male Ayrshire (*46*).

The case of the almost identical appearance of the dark dun F_2 heifer and her Jersey parent agrees well with the findings of Kuhlman (*17*) for Jersey × Aberdeen-Angus crosses. These cases support the conclusion that in the Jerseys any such dilution factor as that in the Guernsey is not normally present.

General White Markings of the Coat

Most investigators have considered that white markings found in the different parts of the coat were due to a piebald factor exhibiting great somatic variation (*19, 21, 43, 48*). This statement of the case seems to the author to have many contradictions, but as this appears to be the popular belief the data will be treated first from this point of view. Table VIII presents this treatment.

TABLE VIII.—*Behavior of the general white markings in the parental and first filial generations*

Sire.	Description of mating.	Offspring.
Taurus Creamelle Hengerveld.	Spotted × solid color.....	2 solid colors, 5 spotted.
Do.....	Spotted × spotted.....	8 spotted, 1 solid color.
Kayan.....	Spotted × solid color.....	3 solid color, 3 spotted.
Do.....	Spotted × spotted.....	3 solid color, 13 spotted.
Lakeland's Poet.....	Solid color × solid color..	1 solid color.
Do.....	Solid color × spotted.....	2 solid color, 3 spotted.
Minor crosses:		
Crossbred 9.....	F_1 spotted carrying solid color × solid color.	2 solid color.
Do.....	F_1 spotted carrying solid color × F_1 spotted carrying solid color.	3 spotted.
Crossbred 10.....	F_1 spotted × spotted.....	1 solid color.
Lady Primrose's Governor of the Fountain.	Spotted × spotted.....	Do.
Delva's University De Kol..	.....do.....	1 spotted.
Johanna Lad Manor De Kol.	Spotted × solid color.....	Do.
Columbia's Fox.....	....do.....	Do.

Two points of importance come out in consideration of these data: First, the white piebald factor must be dominant; second, this factor must be present in the bulls in the heterozygous form, as each bull throws some solid-color animals. The first conclusion is not strange, for it is to be expected that the factor is dominant, recessive, or perhaps intermediate in its effect. The fact could, however, be just as well explained by the presence of a dominant factor for white in a given part of the

body and the simultaneous presence of other recessive factors for white in the rest of the body. The second conclusion could be explained on chance sorting, in which chance had given us nine heterozygous bulls. Such a conclusion would seem unlikely, unless the piebald condition is lethal when homozygous. Furthermore, the piebald condition is always favored in the ratios obtained as this work and that of Kiesel (*18*) have shown.

The work of others furnishes further supporting evidence for the view that the white markings are brought about not by one factor but by the interaction of many. Boyd (*10*) and Nabours (*26*) have shown that the white face of the Hereford is dominant. In collecting evidence for cases parallel to their case of animals white with red and with black ears Lloyd-Jones and Evvard (*20*) found Storer (*20*), Wilsdorf (*48*), and others had described similar cases. Chillingham and Park cattle have such dominant markings of white body coat with black ears; and Pembroke and Highland cattle, which have a coat of almost identical pattern, have the character recessive. Wilson (*51*) further fills in the gap by describing cases of cattle which were all white. Besides these examples the belt of the Dutch-belted cattle has been shown to be separately inherited. Thus it would seem that there are many cases where a given kind of white is separately inherited.

All of these cases are important for the interpretation of the coat of the roan Shorthorn. Already some of those differences in behavior of the white have been used for parallels to explain the peculiar ratios obtained in these Shorthorn cattle studies (*20*, *58*). It remains, however, to be shown that there is any difference in the inherited white throughout the different parts of the coat before this parallelism is established. Allen (*1*) has made a beginning at this kind of attack by his studies on the distribution of these white markings in mammals and birds. His studies as to the location of the centers of these spots are in general found to check well with this study. The location of the areas may be given as follows: The forehead, the throat, a band across the shoulders often extending to the belly, an irregular spot on the rump including some of the tail set, irregular spots on the flanks, lower half of tail above switch, belly from brisket to inguinal region and any leg as a coronet, or as a short or long stocking.

The data on these crossbreds as above presented are well suited to this novel analysis. The markings of both parents and offspring have been carefully examined and described in writings, by drawings, and with photographs. The areas were found to fall naturally into the groups above mentioned. The material to determine the behavior in inheritance of the various groups is available.

The general practice followed throughout the study of these individual spots is to consider each area separately. The general conclusions for the behavior of these areas are then given. If there are any

cases which appear anomolous to the conclusion, these are considered together with their color pedigree. The summary and general conclusions are reserved for the end of this section on white markings.

WHITE MARKINGS OF THE FACE

The markings of the face have been divided into the classes familiar to most breeders: Star, star and snip, blaze, and solid color. In all of these studies the presence of a few white hairs is considered as star or snip, etc., according to the place of its appearance.

The behavior of the F_1 progeny markings is shown in Table IX.

TABLE IX.—*Behavior of the white markings on the face in the parental and first filial generations*

Sire.	Description of mating.	Offspring.
Taurus Creamelle Hengerveld.	Star × solid color	8 solid + 3 star.
Do	Star × star	1 solid + 1 star, 1 star snip.
Do	Star × F_1 blaze carrying star.	1 blaze.
Do	Star × F_1 solid color carrying star.	1 star.
Kayan	Solid color × solid color	9 solid color.
Do	Solid color × star	10 solid color.
Do	Solid color × blaze	3 solid color.
Lakeland's Poet	Solid color × solid color	Do.
Do	Solid color × star	1 solid color + 1 star.
Do	Solid color × blaze	1 solid color.
Minor crosses:		
Crossbred 9	F_1 solid color carrying star × solid.	2 solid color.
Do	F_1 solid color carrying star × F^1 solid carrying star.	2 star, 1 solid color.
Crossbred 10	F_1 solid carrying star × star.	1 solid color.
Lady Primrose's Governor of the Fountain.	Star × solid color	Do.
Johanna Lad Manor De Kol.	....do	Do.
Columbia's Fox	Solid color × solid color	Do.

As a whole, Table IX indicates that white markings of the face are suppressed in the F_1 offspring when one of the parents is solid color. There is one exception to this interpretation. Heifer 12 had no mark and came from Taurus Creamelle Hengerveld (large star) and College Gem (very small star). It may be, of course, that this star in College Gem is hair just turning gray with age. This does not seem likely, however, and it seems best to consider this a case against so simple an hypothesis as a single recessive. Four other cases offer exceptions if it should prove true that their solid-color parents are genetically solid colored. Unfortunately, only two of these cases can be pedigreed, as they alone come from breeds recording color markings as part of their registration for the herd book. The first of these (Columbia's Brown Bessie) has her color pedigree given in Table X.

The pedigree of this animal has so much recorded white in it that it is possible to make the appearance of white on any of her offspring quite likely from the standpoint of chance inheritance of single factors when she is mated to white bulls.

TABLE X.—*Pedigree of Columbia's Brown Bessie*

Maine Agr. Exp. Sta.—Standard Pedigree Blank.

COLUMBIA'S BROWN BESSIE. Sex ♀

No. 148531.

♂	No. 47278. BROWN BESSIE'S SON 6TH. Solid color, black tongue and switch.	No. 34550. ♂ BROWN BESSIE'S SON. Solid color, black tongue and switch.	No. 17576. ♂ COMBINATION 3D. Solid color, black switch.	No. 4389. COMBINATION. ♂ Solid color, black points.
				No. 29330. COMA. ♀ Solid color, black tongue and switch.
			No. 74997. ♀ BROWN BESSIE. White flanks, belly, and tongue; switch black.	No. 7890. VOLEO. ♂ Solid color, white tongue, black switch.
				No. 74996. BROWN FLORA. ♀ Solid color, black tongue and switch.
		No. 37496. ♀ FANCY BEE. Star, white flanks; fleck on right thigh; white armpits, belly, forefeet, and hind socks, and switch.	No. 9777. ♂ FANCY'S HARRY. White forefeet; white hind stockings; white tongue; mixed switch.	No. 3445. LORD HARRY. ♂ Solid color.
				No. 2876. LANDSEER'S FANCY. ♀ Eyelids buff; star; white on shoulder; white forefeet, hind legs; belly white.
			No. 9807. ♀ BEESWAX. Gray; white in both flanks, left hip, both hind legs, and left forefeet; white belly.	No. 1404. TOP SAWYER. ♂ Solid squirrel gray; black tongue and switch.
				No. 1870. BESMA 3D. ♀ Solid color, black tongue, hoof, and switch.
♀	No. 103191. COLUMBIA'S FANCY. Solid color, dark tongue, and black switch.	No. 26853. ♂ TURBIGO'S BEST SON. Solid color, black tongue and switch.	No. 18208. ♂ TURBIGO. Solid color, black tongue and switch.	No. 3533. TORMENTOR. ♂ Gray; dark shading; small star; white belly, front of hind legs, and fore ankles.
				No. 24757. MAJESTIC. ♀ Solid color, white tongue, and brown switch.
			No. 49119. ♀ ZORANDA. White spot on each flank, on right thigh; white belly; white tongue and switch.	No. 15664. RUBY'S HARRY. ♂ Spot on face; white on right arm, flanks, belly, and left hind leg; right hind stocking white; mixed switch.
				No. 10592. MISS EVERDEEN. ♀ Partly colored.
		No. 80927. ♀ FLOSSIE LANDSEER. White fleck on each flank, armpits, and belly; white on thigh; hind legs, tongue, and switch white.	No. 24886. ♂ FANCY'S HARRY 7TH. Mixed black and white switch; white tongue.	No. 9777. FANCY'S HARRY. ♂ White on forefeet; white hind stockings; white tongue; mixed switch.
				No. 32989. RUBY TORMENT. ♀ Little white on brisket and flanks; white belly; white on legs; white switch.
			No. 75581. ♀ ALETHA OF MOUNT PLEASANT. Solid color, black tongue and switch.	No. 11578. SIR FLORIAN. ♂ Solid color, black tongue and switch.
				No. 33487. ENNA. ♀ Solid color, black tongue and switch.

Fancy Bee (37496), the granddam on the father's side, had a star which, if the hypothesis that the star is due to a single recessive is correct, would have been transmitted to Brown Bessie's Son 6th in the heterozygous form (single dose). This gives an even chance that Columbia's Brown Bessie carries a star.

The case of Lakeland's Poet, father of Heifer 11, is not quite so good. There is still, however, a good chance that he carries this star, as may be seen from his color pedigree (Table XI).

TABLE XI.—*Pedigree of Lakeland's Poet*

Maine Agr. Exp. Sta.—Standard Pedigree Blank.

Sex ♂				
LAKELAND'S POET.	♂			
No. 102603.	MABEL'S POET.	No. P. S. 2591. ♂ CAIEST. White under chest; white on forelegs; switch white.	No. 2207. ♂ S. FONTAINE'S KING. White on each stifile; tail and tongue white.	No. 1559. S. BOYLE. ♂ White spot on forehead; tail and tongue white.
	No. 65780. Black tongue and switch; some white on bricket; speck on left side of belly, and patch on belly near left flank.			No. 2537. D. FONTAINE 4TH. ♀ Fawn and white; white patch on forehead; white spot behind right shoulder.
			No. 3582. ♀ D. OXFORD LASS. White across withers; tongue black; tail white.	No. 928. COUNT WOLSELEY. ♂ Brown, solid color; tail and tongue black.
				No. 2252. D. OXFORD PRIMROSE. ♀ Fawn; white stripe on left shoulder.
		No. P. S. 6311. ♀ MABEL 35TH. Solid color, red muzzle.	No. 1559. ♂ S. BOYLE. White spot on forehead; tail and tongue white.	No. 1242. S. GOLDEN LAD. ♂ Gray-fawn, solid color; tongue and switch black.
				No. 3214. D. TOOTSIE. ♀ Gray; white on each stiffle; white ring in tail; tongue white.
			No. 3213. ♀ D. MABEL 23D. Tongue and tail black dappled on chine.	No. 390. S. EVERTON KING. ♂ Gray, solid color; tongue black and white.
				No. 1125. D. MABEL 13TH. ♀ Brown; white spot on loins; white speck behind each shoulder; tail black.
	♀	No. 53844. ♂ PEDRO'S POLO. Solid color, black tongue and switch.	No. 45486. ♂ GENERAL MARIGOLD. Solid color, black tongue and switch.	No. 34969. MAJOR POLO. ♂ Solid color; brown tongue and switch.
				No. 88186. MARY IDAGOLD. ♀ Solid color except little white on belly; black tongue and switch.
	NORA OF MONMOUTH 2D. White on each foreankle and knee; white bricket; light tongue and mixed switch.		No. 88543. ♀ RIOTERS PRETTY BELLE. Solid color except belly, hind legs, tail, and switch white; white tongue.	No. 26015. PEDRO OF LINDEN. ♂ Solid color; black tongue and switch.
				No. 75273. RIOTERS PRETTY PEARL. ♀ Solid color; black tongue and switch.
	No. 214693. Spot on each foreankle and knee; white bricket; light tongue and mixed switch.	No. 152789. ♀ NORA OF MONMOUTH. Solid color, light tongue, black swtch.	No. 45313. ♂ LORD HARRY'S HUGO. Solid color; black tongue and switch.	No. 34117. FLORIANS FANCY. ♂ Solid color; black tongue and switch.
				No. 83743. PRIDE OF PIONEER. ♀ Solid color except little white on belly; white tongue and black switch.
			No. 135194. ♀ PRIDE OF PIONEER 2D. Solid color, black tongue and switch.	No. 34117. FLORIANS FANCY. ♂ Solid color; black tongue and switch.
				No. 83743. PRIDE OF PIONEER. ♀ Solid color except little white on belly; white tongue and black switch.

In consideration of the single-factor hypothesis for the different white areas the following animals are of especial interest: S. Boyle, D. Fontaine 4th, S. Fontaine's King, Rioter Pretty Belle, and Caiest.

The sire of the dam of the father of Lakeland's Poet is known to have been star. This would go to his father's dam as a single dose. The chance of Mabel's Poet 65780 carrying it would be even and of Lake-

land's Poet receiving it 1 in 4. The only pedigrees which we have been able to study have shown a fair chance for the animals to carry the star. There is in this pedigree an apparent exception to the recessive quality of star, as the mating of S. Boyle (star) by D. Fontaine 4th (star) gave a solid-color offspring.

Some interesting cases of the reappearance of the star after its disappearance in the F_1 generation may be mentioned. Taurus Creamelle Hengerveld mated to No. 12, the F_1 exception noted above, gave as the result of this back cross a star. Likewise, when Crossbred 0 (solid color carrying star) is inbred to the solid-color females carrying star, he gave two stars and one solid-color offspring. These F_2 offspring would indicate a segregation of the star determiner from solid color.

MARKINGS OF THE THROAT

In cattle the white on the neck may be divided into two classes, according to the center of its occurrence. These are (1) a white area on the throat and (2) an extension of the white belt of the withers into an irregular white area on the crest of the neck. This last marking is quite rare. In these experiments we have nothing which could be called this extension, and shall therefore have no opportunity to consider its behavior. The white spot on the throat as it appeared in the parents and in the offspring is given in Table XII.

TABLE XII.—*Behavior of the white markings on the throat in the parental and first filial generations*

Sire.	Description of mating.	Offspring.
Taurus Creamelle Hengerveld.	Throat spot × solid color.	13 solid + 2 spot.
Do	Throat spot F_1 solid carrying white.	1 white.
Do	Throat spot × F_1 solid color.	1 solid color.
Kayan	Solid color × throat spot.	3 solid color.
Do	Solid color × solid color.	19 solid color.
Lakeland's Poet	Solid color × throat spot.	3 solid color.
Do	Solid color × solid color.	Do.
Minor crosses:		
Crossbred 0	F_1 solid carrying throat spot × solid color.	2 solid color.
Do	F_1 solid carrying throat spot × F_1 solid carrying throat spot.	1 throat spot × 2 solid color.
Crossbred 10	F_1 solid color × solid color.	1 solid color.
Lady Primrose's Governor of the Fountain.	Throat spot × solid color.	Do.
Johanna Lad Manor De Kol	do	Do.
Columbia's Fox	Solid color × solid color.	Do.

The conclusion to be drawn from Table XII is that the white markings of the throat are recessive. There are two cases where the behavior of the F_1 offspring is doubtful: Crossbreds 6 and 20 from the same dam,

Maple Grove Netta, and by the same bull, Taurus Creamelle Hengerveld. Both animals have a throat spot similar to that of their sire. It would seem that Maple Grove Netta must also have this mark as a single dose. She is, however, given as unmarked by the herd book. Unfortunately, the Ayrshire herd books allow the record to be made as red and white without giving the actual location of these marks. We can not, therefore, trace definitely the white spot. The color pedigree of Maple Grove Netta is given to show the large amount of white in the pedigree and also the difficulty in tracing the throat mark (Table XIII).

TABLE XIII.—*Pedigree of Maple Grove Netta*

Maine Agr. Exp. Sta.—Standard Pedigree Blank

MAPLE GROVE NETTA. Sex ♀

No. 29307.				
No. 15474. Dark red, with white spot on forehead; flanks white; white strip on forelegs; white switch. ♀ LENETTA.	No. 10034. ♂ BARCHESKIE COPESTONE. Brown and white.	No. "5665." ♂ BARCHESKIE MAY KING. Imported.	No. ♂	No. ♂
				No. ♀
			No. ♀	No. ♂
				No. ♀
		No. "11918." ♀ ORANGE BLOSSOM OF BARCHESKIE. Imported.	No. ♂	No. ♂
				No. ♀
			No. ♀	No. ♂
				No. ♀
	♀	No. 5389. ♂ GLOUCESTER. Dark red, with heart-shaped spot of white in forehead; small strip of white back of shoulders; two small white spots back of left shoulder; white on both flanks.	No. 4227. ♂ GEORGE A. F. Dark red and white.	No. 2469. GLENCARNE. ♂ Dark red; little white; white in forehead; white spot on each shoulder; off hip and both flanks white; spotted legs.
				No. 4464. QUEEN OF AVY 3D. ♀ Red and white; three-eighths white; some white in forehead inclosing red spot.
			No. 9358. ♀ MALINDA B. Dark red; white spot in forehead; white on flank and tail.	No. 2083. HEBRAN. ♂ Red and white.
				No. 6190. QUEEN LINDETTA. ♀ Dark red; a little white; white spot in forehead.
		No. 11224. ♀ ATHENIA. Dark red and white; forehead white with two narrow strips of red inclosed; spot of white above left nostril; smaller spot above right; strip across shoulders; both thighs white; band of white across base of tail.	No. 4213. ♂ LINWOOD. Dark red and white; white splash in forehead.	No. 3862. CLIMAX. ♂ Red and white.
				No. 6579. LADY TEAZLE. ♀ Reddish roan; V of white in forehead; white strip over loin and shoulders.
			No. 4542. ♀ MAID OF ATHENS. Red and white.	No. 1961. LORD DERBY. ♂ White and red; mostly white.
				No. 4548. STRATHAVEN MAID. ♀ Light red and white.

It is hard to do much with this pedigree in the way of tracing the inheritance of the separate white marks. The presence of a large number of them is shown as many areas carried by a single animal.

On the hypothesis suggested there are two cases of segregation: Taurus Creamelle Hengerveld with a white throat mated to No. 2 solid color carrying white throat gave No. 49, a white-throated offspring. Crossbred 0 when mated to Crossbred 1 both solid color carrying white throat recessively produced Crossbred 25, a white-throated heifer.

MARKINGS OF THE SHOULDERS

The markings occurring in the region of the shoulders may be divided into three categories, depending on the amount of extension of the band across the shoulders. The first of these is a band extending from under the armpits on one side across the withers to the armpits on the other side. The band may be broken in its lower part by pigment, so that all there is left is a band across the withers. This band may be asymmetrical, having a greater area on one side than the other. Unfortunately all of these extensions of this spot of pigment are not present in the herd. Attention will be confined to the presence or absence of the white mark. This treatment is given in Table XIV.

TABLE XIV.—*Behavior of the white markings on the shoulders in the parental and first filial generations*

Sire.	Description of mating.	Offspring.
Taurus Creamelle Hengerveld.	Shoulder band × solid color.	1 spotted right shoulder, 2 shoulder bands, 11 solid color.
Do	Shoulder band × F_1 solid carrying band.	1 solid color.
Do	Shoulder band × F_1 shoulder band.	1 shoulder band.
Kayan	Solid color × spots on left shoulder.	2 solid color.
Do	Solid color × shoulder band.	10 solid color.
Do	Solid color × solid color	9 solid color.
Lakeland's Poet	Solid color × shoulder band.	1 solid color.
Do	Solid color × solid color	5 solid color.
Minor crosses:		
Crossbred 0	F_1 solid carrying shoulder band × solid.	2 solid color.
Do	F_1 solid carrying shoulder band × F_1 solid carrying shoulder band.	2 shoulder bands+1 solid color.
Crossbred 10	F_1 solid color × shoulder band.	1 solid color.
Lady Primrose's Governor of the Fountain.	Shoulder band × solid color.	Do.
Johanna Lad Manor De Kol	do	Do.
Columbia's Fox	Solid color × solid color	Do.

The data of Table XIV would indicate the recessive character of the white markings of the shoulders. On the basis of this conclusion there are two cases of segregation: Crossbred 0 mated to heifers known to carry

this mark but not showing it somatically produced two offspring with shoulder bands and one without it.

There are three apparent exceptions to this recessive interpretation. Two bulls from Maple Grove Netta (No. 6 and 20) have shoulder bands. By the pedigree given in Table XIII it is shown that Maple Grove Netta must have been heterozygous for this mark; consequently it is not to be wondered at that her offspring have it when mated to a bull carrying it. The other case is not quite so easy to reconcile. In the pedigree given in Table XVI with this single-factor hypothesis there are two known possibilities in the fourth generation to have this factor transmitted to Flying Fox's Flora, the mother of the aberrant individual. This doe not leave a great chance for her to have this factor. From her other breeding, however, it would look as if Flying Fox's Flora must carry this white mark.

MARKINGS OF THE RUMP

The white markings of the rump consist chiefly of a spot whose center is the tail set. This spot may be extended by fusion with the patches having as their centers the middle of the flanks. These extensions will be considered as two separate spots located, respectively, on the rump and on the flanks. The behavior of the rump spot from the parents to the offspring is shown in Table XV.

TABLE XV.—*Behavior of the white markings on the rump in the parental and first filial generation*

Sire.	Description of mating.	Offspring.
Taurus Creamelle Hengerveld.	Rump spot × rump spot	2 rump spots.
Do	Rump spot × solid color	10 solid color.
Do	Rump spot × F_1 solid carrying rump spot.	1 rump spot, 1 solid color.
Kayan	Solid color × rump spot	15 solid color.
Do	Solid color × solid color	7 solid color.
Lakeland's Poet	Solid color × rump spot	1 rump spot, 2 solid color.
Do	Solid color × solid color	3 solid color.
Minor crosses:		
Crossbred 0	F_1 solid color carrying rump spot × solid color.	2 solid color.
Do	F_1 solid color carrying rump spot × F_1 solid color carrying rump spot.	1 rump spot.
Crossbred 10	F_1 solid color carrying rump spot × rump spot.	1 solid color.
Lady Primrose's Governor of the Fountain.	Rump spot × solid color	Do.
Johanna Lad Manor De Kol	do	1 rump spot.
Columbia's Fox	Solid color × solid color	1 solid color.

Here, also, the character of the white mark appears recessive in its transmission. There are, however, three exceptions to this view, if these should prove genetically what they appear to be somatically. The

exceptions are Crossbreds 11, 14, 35, and require for their production that the animals Lakeland's Poet and Flying Fox's Flora be heterozygous for the factor producing this white spot.

The single case of this white in the pedigree makes it hard to believe that Flying Fox's Flora carries this mark, even though her two offspring do show it somatically. The case of Lakeland's Poet is not quite so bad, as in his pedigree there are two animals, S. Fontaine's King and Rioter's Pretty Bell, which have their tails recorded as white. Since the tail set is the common center for the rump spot, it is probable that these animals have this spot (Table XVI).

TABLE XVI.—*Pedigree of Flying Fox's Flora*

Maine Agr. Exp. Sta.—Standard Pedigree Blank.

Sex					
♀	FLYING FOX'S FLORA.				
♂	No. 64768. FLYING FOX'S VICTOR. Solid color, black tongue and switch.	No. 61441. ♂ CHAMPION FLYING FOX. Solid color, except white on brisket; white tip to black tongue; black switch.	No. P. S. 2160. ♂ GOLDEN FERN'S LAD. White spot on forehead and withers; tongue and switch white.	No. 1559. BOYLE. ♂ Brown and white; white on forehead; tail and tongue white.	
				No. 4711. GOLDEN FERN. ♀ Dark fawn; solid color; black tail.	
			No. 149740. ♀ SULTANA'S ROSETTE. Solid color; black tongue and switch.	No. P. S. 797. SARABOND. ♂ Dark brown; two white specks on fore fetlocks; tail black and white.	
				No. P. S. 2128. ROSETTE 4TH. ♀ Gray; white on right hip; tail black; dappled under barrel.	
		No. F. S. 8801. ♀ DULCE OF OAKLAND. Solid color; black tongue and switch.	No. ♂	No. ♂	
				No. ♀	
			No. ♀	No. ♂	
				No. ♀	
♀	No. 27051. BLONDDEUNA. Solid color, black tongue and switch.	No. 42000. ♂ DON OF HOOD FARM. Solid color; black tongue and switch.	No. 30212. ♂ PEDRO SIGNAL LANDSEER. Solid color; black tongue and switch.	No. 9033. YOUNG PEDRO. ♂ Solid color; black tongue and switch.	
				No. 60789. SIGNAL MINE 2D. ♀ Solid color; black tongue and switch.	
			No. 82426. ♀ DONNEY POGIS 2D. Solid color; black tongue and switch.	No. 23015. TENNESSEE'S LANDSEER. Few white hairs on left shoulder; small white spot on right flank; white ankles, tongue, and switch.	
				No. 38907. DONNEY POGIS. ♀ Solid color; black tongue and switch.	
		No. 124651. ♀ BLONDE BRIGGS. Solid color; black tongue and switch.	No. 26930. ♂ GEM OF ST. LAMBERT. Solid color; black tongue and switch.	No. 18453. COLUMBINE'S JOHN BULL. ♂ Solid color; black tongue and switch.	
				No. 48577. MISS CARO POGIS. ♀ Solid color; black tongue and switch.	
			No. 67895. ♀ BANGOR MAID. Solid color, except white on belly, brisket; mixed switch; black tongue.	No. 21455. FAUNTLEROY. ♂ Some white on brisket; small white spot on each flank; white tongue; black switch.	
				No. 53605. EUNA'S FIRST. ♀ Solid color, except white spot on each stiffle and flank; white tongue; black switch.	

The white shoulder marks of Golden Fern's Lad and Tennessee's Landseer are of interest in connection with the inheritance of this white. The presence of white spots on the hips of Rosette 4th is of interest,

since this appears to be the only animal known to four generations which could transmit this white to Flying Fox's Flora. Tennessee's Landseer, Fauntleroy, and Euna's First have white marks on the flanks. In connection with the development of the separate factor argument for the individual white spot, the animals Bangor Maid, Boyle, and Sarabond are of interest.

MARKINGS OF THE FLANK

Markings on the flanks of dairy cattle generally consist rather of extension areas from the white on the legs than they do of definitely centered spots. However, from the evidence brought forward by Allen (*1*) it would appear that this is a definite area. It consequently will be treated as such. Table XVII gives such treatment of the parental and F_1 generation.

TABLE XVII.—*Behavior of the white markings on the flanks in the parental and first filial generation*

Sire.	Description of mating.	Offspring.
Taurus Creamelle Hengerveld.	Spotted left flank × solid color.	3 spotted, 10 solid color.
Do	Spotted × spotted	1 solid color.
Do	Spotted × F_1 solid color carrying spotted.	1 spotted.
Do	Spotted × F_1 spotted	Do.
Kayan	Solid color × solid color	9 solid color.
Do	Solid color × spotted flanks.	13 solid color.
Lakeland's Poet	Solid color × spotted flanks.	2 solid, 1 left flank spotted.
Do	Solid color × solid color	3 solid color.
Minor crosses:		
Crossbred 0	F_1 solid color carrying spotted flanks × F_1 spotted flank.	2 spotted flanks.
Do	F_1 solid color carrying spotted flanks × solid.	2 solid color.
Do	F_1 solid color carrying spotted flanks × F_1 spotted flanks carrying solid color.	1 solid color.
Crossbred 10	F_1 solid color carrying spotted flanks × spotted flanks.	Do.
Lady Primrose's Governor of the Fountain.	Spotted flanks × solid color.	Do.
Johanna Lad Manor de Kol	do	1 spotted right flank.
Columbia's Fox	Solid color × solid color	1 solid color.

Here, again, the white areas are generally suppressed in the offspring when an animal bearing them is crossed to a solid-color animal. There are six cases apparently at variance with this conclusion. Five of them may be easily seen by their pedigrees to have had an animal carrying the mark so close that either the aberrant parent would be heterozygous or else had an even chance for a single dose of the factor. Of the four

exceptions from Taurus Creamelle Hengerveld, two (Nos. 6 and 20) are from Maple Grove Netta. The pedigree of this animal given above shows that she must be heterozygous for this mark on a single-factor hypothesis. No. 14 by the same bull from Flying Fox's Flora is also an exception. In this case the parent expected to transmit this mark is in the second generation. The same is also true for the case of the two exceptions from Lakeland's Poet, for the parent carrying this mark is also in the second generation. It is interesting in this connection to compare the size, shape, and position of the flank markings of a daughter of Lakeland's Poet with the flank markings of her offspring from a straight F_2 generation. It will be noted that they are almost identical.

The remaining case is that of No. 3 from Johanna Lad Manor De Kol and Flora's Golden Poetess. The solid-color parent, Flora's Golden Poetess, has a white-flanked grandfather (Mabel's Poet) and granddam (Imp. Lady Grandiflora). It is not strange, then, that she should carry white for the flank.

MARKINGS OF THE TAIL

TABLE XVIII.—*Behavior of the white markings on the tail in the parental and first filial generations*

Sire.	Description of mating.	Offspring.
Taurus Creamelle Hengerveld.	Lower half white × corner half white.	2 half white.
Do	Lower half white × solid color.	3 lower half white, 9 solid color.
Do	Lower half white × F_1 lower half white.	2 lower half white.
Kayan	Solid color × upper half white.	3 solid color.
Do	Solid color × lower half white.	11 solid color.
Do	Solid color × solid color	8 solid color.
Lakeland's Poet	Solid color × lower half white.	1 lower half white, 1 solid color.
Do	Solid color × solid color	3 solid color.
Minor crosses:		
Crossbred 0	Solid color carrying lower half white × solid color.	2 solid color.
Do	Solid color carrying lower half white × F_1 solid color carrying half white.	2 half white + 1 solid color.
Crossbred 10	Solid color × lower half white.	1 solid color.
Lady Primrose's Governor of the Fountain.	Lower half white × solid color.	Do.
Johanna Lad Manor De Kol	do	Do.
Columbia's Fox	Solid color × solid color	Do.

The markings of the tail may be divided into four general groups: In the first only the switch is white; in the second the hair just above the switch is white; in the third group about half the tail is white; and in the fourth group the whole tail is white. Much observation of the switch and tail colors in cattle has led to the view that the color of the hair in

the switch is separate in its behavior from the rest of the tail. These areas will be studied separately. The cases of the ring just above the switch and of the whole tail white will not be studied, as these marks are not present in the herd. The choice of the broad quantitative group lies in a study of the length of those white areas. The length of the white area on the tail was measured and found to be between one-third and one-half the total length of the tail. The data have been considered on the basis of this and made two qualitative groupings: (1) half white and (2) solid color (Table XVIII).

TABLE XIX.—*Pedigree of Lassie of M. F.*

Maine Agr. Exp. Sta.—Standard Pedigree Blank.

Sex ♀				
LASSIE OF M. F.	♂	No. 55553. ♂ HOOD FARM POGIS 9TH. Solid color, black tongue and switch.	No. 40684. ♂ HOOD FARM POGIS. Solid color, black tongue and switch.	No. 17165. OONAN'S POGIS. ♂ Solid color, black tongue and switch.
				No. 60738. KATHLETTA'S FANCY. ♀ Solid color, black tongue and switch.
			No. 76106. ♀ FIGGIS. Brisket, armpits, belly, and hind stockings white; white on right foreankle and left foreleg; dark hairs in white switch.	No. 20883. SOPHIE'S TORMENTOR. ♂ Star; brisket and left stifle white; white on flanks, belly, forefeet, and hind legs; white switch.
				No. 48326. BIRDSEY'S SURPRISE. ♀ Belly and hind legs white; black and white switch; black tongue.
No. 234891.	No. 92626. POGIS 9TH OF HOOD FARM. Solid color, black tongue and switch.	No. 198780. ♀ BELLE 7TH OF HOOD FARM. Solid color, black tongue and switch.	No. 64268. ♂ HOOD FARM GOLDEN LAD. Solid color, black tongue and switch.	No. 57788. FINANCIAL KING. ♂ Solid color, dark tongue and switch.
				No. 114438. SILENT. ♀ Solid color, black tongue and switch.
			No. 180932. ♀ TONOMA 22D OF HOOD FARM. Solid color, black tongue and switch.	No. 25204. TORONO. ♂ Star; white stifle; flanks, belly, right forearm, fore pasterns, and hind legs, half of tail and switch white.
				No. 147794. OONAN 14TH OF HOOD FARM. ♀ Solid color, black tongue and switch.
No. 297736.	♀	No. 80437. ♂ HOOD FARM GOLDEN FERN'S LAD. Solid color, black tongue and switch.	No. 65300. ♂ IMP. GOLDEN FERN'S LAD. Star; white on stifles and right flank; streak on left flank/ little on belly and legs; white tongue and switch.	No. P. S. 1559. BOYLE. ♂ Brown and white spot on forehead, tail, and white tongue.
				No. P. S. 4711. GOLDEN FERN. ♀ Dark fawn; solid color; black tail.
			No. 195756. ♀ SCOT'S BELLE. Solid color, black tongue and switch.	No. P. S. 2153. GREAT SCOT. ♂ Gray-brown; solid color.
				No. P. S. 5431. PALLUS. ♀ Gray; solid color; tongue and tail black.
	No. 212614. ♀ BELLE 21ST OF HOOD FARM.		No. 64268. ♂ HOOD FARM GOLDEN LAD. See above.	No. ♂
				No. ♀
			No. 184981. ♀ HOOD FARM PRIDE. Solid color, black tongue and switch.	No. 56742. OSCAR OF MAPLECROFT. ♂ Solid color, black tail and tongue.
				No. 111172. EMMA HOTCHKISS. ♀ Solid color; white tongue; black switch.

HOOD FARM FERN'S LASSIE. Solid color, black tongue and switch.

The general conclusion from these data is that white on the tail is generally suppressed in the offspring when the animal bearing it is crossed with a solid-color animal. In this, also, there are some of the same irregularly behaving individuals which appeared in the previous

studies. Of the offspring of Taurus Creamelle Hengerveld, No. 14, 16, and 50 behave in contradiction to expectation. Of these the anomalous parents of No. 14 and 46 are available for study. The same difficulty of reconciling the behavior of No. 14 with expectation is experienced as in the preceding case. There are only three parents up to the fifth generation which carry the white.

It will be noted from the color pedigree of Lassie of M. F. that the chance of her carrying white for the legs is good, since two parents, Figgis and Imp. Golden Ferris Lad, both had these marks. The same is also true for markings on the tail (Table XIX).

The case of Lassie of M. F. is much better, as she had both of her grandfathers carrying the factor. The other exception is that of No. 11 by Lakeland's Poet. It will be noted in the previous pedigree that there is a good chance for this animal to carry the factor for a white tail, as the description indicates that this mark is carried by his father.

MARKINGS OF THE BELLY

TABLE XX.—*Behavior of the white markings on the belly in the parental and first filial generations*

Sire.	Description of mating.	Offspring.
Taurus Creamelle Hengerveld.	All white × inguinal spot.	2 all white + 1 solid color + 1 inguinal spot.
Do	All white × fore part white.	2 all white.
Do	All white × all white	1 all white.
Do	All white × solid color	5 all white + 1 solid color.
Do	All white × F_1 all white	2 all white.
Kayan	Inguinal spot × all white	7 inguinal spot, 2 belly white to navel, 2 belly all white, 3 solid color.
Do	Inguinal spot × solid color.	4 inguinal spot, 4 solid color.
Lakeland's Poet	Solid color × inguinal spot.	1 inguinal spot.
Do	Solid color × all white	3 all white.
Do	Solid color × solid color	2 solid color.
Minor crosses:		
Crossbred 0	Fore and hind part white carrying solid color × solid color.	Do.
Do	Fore and hind part white carrying solid color × all white.	1 all white + 1 solid color + 1 half white.
Crossbred 10	Spot in inguinal region × all white.	1 solid color.
Lady Primrose's Governor of the Fountain.	All white × solid color	Do.
Johanna Lad Manor De Kol	do	1 all white.
Columbia's Fox	Solid color × solid color	1 inguinal spot.

White on the belly takes a variety of patterns, depending largely on the method of extension of these areas. The primary area, if it may be spoken of as such, is a white spot in the region of the udder. This is practically always present when any of the other extensions toward

the brisket are present. Since the data on the extension areas are rather limited, it has been deemed well to consider only this inguinal spot and leave the extension factors for future study (Table XX).

It is obvious at a glance that this white on the belly behaves quite differently from the white markings on the rest of the body. The general conclusion to be drawn from a study of Table XX is that white in the region of the udder behaves as if it were a dominant. There is unfortunately one real exception to this, in that No. 13 has a white throat and inguinal spot, when his parents are both solid color. For the case it must be said that the description of the parent, Columbia's Fox, had to be taken from the herd book, as this animal was sold without description. It is quite probable that a small white spot would escape the one making the record for registry, so that when it is possible to check this case it may be that the required spots will be found.

Should the interpretation of a dominant for this case be correct, the expectation and realization for the various classes would be as follows:

Inguinal spot × inguinal spot = 3 spots to 1 solid color. The actual figures obtained are 21 to 6. Inguinal spot × solid color would be expected to give 1 to 1; the experimental results obtained are 10 to 8.

WHITE MARKINGS OF THE LEGS

The markings of the legs may be divided into four general classes: (1) Animals which are solid color; (2) animals with a white ring on the coronet and extending a short distance above it; (3) the further extension of this white into a white sock; and (4) its still further extension into a white stocking. There are other markings, but these are the most common and will be the only ones considered.

TABLE XXI.—*Behavior of the white markings on the legs in the parental and first filial generations*

LEFT FORELEG

Sire.	Description of mating.	Offspring.
Taurus Creamelle Hengerveld	Short stocking×long stocking	2 long stockings.
Do	Short stocking×short stocking	1 short stocking.
Do	Short stocking×solid color	1 short, 10 solid color.
Do	Short stocking×F_1 long stocking	1 long stocking.
Do	Short stocking×F_1 short stocking	1 short stocking.
Kayan	Solid color×long stocking	10 solid color.
Do	Solid color×short stocking	2 solidcolor.
Do	Solid color×solid color	10 solid color.
Lakeland's Poet	do	3 solid color.
Do	Solid color×long stocking	2 solid color+1 long stocking.
Minor crosses; Crossbred 0	Solid color carrying white×solid color.	2 solid color.
Do	Solid color carrying white×solid color carrying white.	1 spot above knee+1 small white spot on coronet+1 short stocking.
Crossbred 10	Solid color carrying white×solid color.	1 solid color.
Lady Primrose's Governor of the Fountain.	Long stocking×solid color	Do.
Johanna Lad Manor De Kol	do	Do.
Columbia's Fox	Solid color×solid color	Do.

TABLE XXI.—*Behavior of the white markings on the legs in the parental and first filial generations*—Continued

RIGHT FORELEG

Sire.	Description of mating.	Offspring.
Taurus Creamelle Hengerveld	Long stockings×long stockings	1 long stocking.
Do	Long stockings×short stockings	1 short stocking.
Do	Long stockings×solid color	10 solid color, 1 short stocking.
Do	Long stockings×F_1 long stockings	1 long stocking.
Do	Long stockings×F_1 short stockings	Do.
Kayan	Solid color×solid color	12 solid color.
Do	Solid color×short stockings	2 solid color.
Do	Solid color×long stockings	8 solid color.
Lakeland's Poet	Solid color×solid color	3 solid color.
Do	Solid color×long stockings	2 solid color, 1 long stocking.
Minor crosses;		
Crossbred 9	Solid color carrying white stockings×solid color.	2 solid color.
Do	Solid color carrying white stockings×solid color carrying white stockings.	1 white stocking+1 white spot above knee+1 white on coronet.
Crossbred 10	Solid color carrying short stockings ×solid color.	1 solid color.
Lady Primrose's Governor of the Fountain.	White stockings×solid color	Do.
Johanna Lad Manor De Kol	Long white stockings×solid color	Do.
Columbia's Fox	Solid color×solid color	Do.

LEFT HINDLEG

Taurus Creamelle Hengerveld	Long white stocking×F_1 short stocking.	1 long white stocking.
Do	Long white stocking×F_1 long stocking.	Do.
Do	Long white stocking×long white	3 long white stockings.
Do	Long white stocking×solid color	7 solid color, 1 long white, 3 short.
Do	Long white stocking×short stocking.	1 short stocking.
Kayan	Solid color×long white stocking	12 solid color.
Do	Solid color×long stocking	10 solid color.
Lakeland's Poet	Solid color×solid color	3 solid color.
Do	Solid color×long stockings	1 spot on thigh, 2 solid color.
Minor crosses;		
Crossbred 9	Solid color carrying white×solid color.	1 solid color.
Do	Solid color carrying white×solid color carrying white.	1 long stocking, 1 small white spot above coronet.
Crossbred 10	Solid color carrying white×solid color.	1 solid color.
Lady Primrose's Governor of the Fountain.	Long stockings×solid color	Do.
Johanna Lad Manor De Kol	....do	1 short stocking.
Columbia's Fox	Spot on thigh×solid color	1 solid color.

RIGHT HINDLEG

Taurus Creamelle Hengerveld	Long white stockings×long white stockings.	3 long white stockings.
Do	Long white stockings×solid color	4 short stockings, 2 long white stockings, 5 solid color.
Do	Long white stockings×F_1 long white stockings.	2 long white stockings.
Kayan	Solid color×solid color	10 solid color.
Do	Solid color×long white stockings	12 solid color.
Lakeland's Poet	Solid color×solid color	3 solid color.
Do	Solid color×long white stockings	2 solid color, 1 white spot on flank.
Minor crosses;		
Crossbred 9	Solid solor carrying white stockings×solid color.	2 solid color.
Do	Solid color carrying white stockings×solid color carrying white stockings.	1 long white stocking+2 solid color.
Crossbred 10	Solid color carrying white stockings×solid color.	1 solid color.
Lady Primrose's Governor of the Fountain.	Long white stockings×solid color	Do.
Johanna Lad Manor De Kol	....do	Do.
Columbia's Fox	Solid color×solid color	Do.

From unpublished data collected by Dr. A. H. Sturtevant, of Columbia, and the writer on horses it was shown that the frequency of white on a given leg was markedly different. The order of appearance is left hind, right hind, left fore, and right fore. This conclusion agrees with what Brewer (*11*) had already published in 1882, unknown to us, as to the frequency of these marks. It has seemed, therefore, that in this study the individual leg markings should be treated separately (Table XXI).

TABLE XXII.—*Pedigree of Flora's Golden Poetess*

Maine Agr. Exp. Sta.—Standard Pedigree Blank.

Sex ♀				
FLORA'S GOLDEN POETESS.	♂	No. 65780. ♂ MABEL'S POET. Some white on brisket; speck on left side of belly and patch on belly near left flank; black tongue and switch.	No. P. S. 2591. ♂ CAIEST. White under chest; fore legs, switch white.	No. 2207. S. FONTAINE'S KING. ♂ White on each stifle; tail and tongue white.
				No. 3582. D. OXFORD LASS. ♀ White across withers; tongue black; tail white.
			No. P. S. 6311. ♀ MABEL 35TH. Solid color, red muzzle.	No. 1559. S. BOYLE. ♂ White spot on forehead; tail and tongue white.
				No. 3213. D. MABEL 23D. ♀ Tongue and tail black; dappled on chine.
No. 264927.	No. 81118. FONTAINES CAIEST. Solid color, black tongue and switch.	No. 195762. ♀ FONTAINE'S BROWN DAISY. Solid color, black tongue and switch.	No. P. S. 2591. ♂ CAIEST. See above.	No. ♂
				No. ♀
			No. P. S. 6325. ♀ BROWNY'S BEAUTY. Tongue and switch black.	No. 1690. S. MARION. ♂ Solid color, black tongue and switch.
				No. F. S. 7623. D. BEAUTY BROWNY. ♀ Black points.
	♀	No. 64768. ♂ FLYING FOX'S VICTOR. Solid color, black tongue and switch.	No. 61441. ♂ CHAMPION FLYING FOX. Solid color, except white on brisket; white tip to black tongue; black switch.	No. P. S. 2160. GOLDEN FERN'S LAD. ♂ White spot on forehead and withers; tongue and switch black.
				No. 149740. SULTANA'S ROSETTE. ♀ Solid color, black tongue and switch.
			No. F. S. 8801. ♀ DULCE OF OAKLAND. Solid color, black tongue and switch.	No. ♂
				No. ♀
	No. 219544. FLYING FOX'S GRANDIFLORA. Solid color, black tongue and switch.	No. 173908. ♀ IMP. LADY GRANDIFLORA. Spot on left hip; white on right stifle and hind fetlocks; black tongue and switch.	No. 52915. ♂ MONA'S GLORY. Solid color, black tongue and switch.	No. P. S. 1242. GOLDEN LAD. ♂ Solid color, tongue and switch black.
				No. P. S. 3983. MONA 8TH. ♀ Spots in forehead; tail white; white patch on each stifle.
			No. 165772. ♀ LADY GRANDIFLORA. Solid color, black tongue and switch.	No. 1242. GOLDEN LAD. ♂ Solid color, black tongue and switch.
				No. F. S. 6407. GRANDIFLORA. ♀ Solid color, tail and tongue black.

The general conclusion is that these white areas are generally suppressed in the offspring when the animal bearing them is crossed to a solid-color animal. Should this be interpreted as being due to a single recessive factor, several of the experimental animals have white markings against this interpretation. Two of these animals are anomolous to this in every foot. These are Crossbreds 11 and 35. Study of the pedigree of Lakeland's Poet, the sire of these animals, shows that he had a good

chance to carry this white, as his mother, Nora of Monmouth II, had white ankles and a white knee, and his grandfather, Caiest, had four white feet. The case of Flying Fox's Flora is not so clear. The only ancestor in the four generations of her pedigree who carried white feet is Tennessee's Landseer. The chances of her carrying factors for the production of these feet derived from this animal are small, as the animal bearing such marks is in the fourth generation.

It will be noted that the hind feet have more exceptions than the fore feet. Three of these females exceptional in the left hind foot are also exceptions in the right hind foot. These three exceptions are Lassie of M. F., Eventime 4th, and Hearthbloom. Only one of these animals, Lassie of M. F., is available for study. The chance of her carrying white is rather good, as she has two ancestors in the third generation who could transmit this to her. The other exceptions are Flora's Golden Poetess, with offspring having white on the left hind feet; Columbia's Brown Bessie, and Orono Ellen, with offspring with white on the right hind feet. The chance of Flora's Golden Poetess carrying the white seems good from the above pedigree. Caiest in the third generation and Imp. Lady Grandiflora both carry white. This makes it certain that the mother and the two grandparents on the father's side each has one dose of the factor (Table XXII). The case is even stronger for Columbia's Brown Bessie, as in her ancestry both of her grandmothers have white feet. In fact, the wonder is why she did not transmit more white to her offspring.

Summary of the Evidence on the Separate Inheritance of White Markings

A general summary of the behavior of the white markings just studied seems necessary for a clear understanding of the conclusions based on this study and their bearing on the general problem of coat-color inheritance. As has been previously pointed out, the limiting of the study to individual spots attacks the problem in an entirely novel way. Such analysis is made necessary because of the peculiar ratios which have been obtained in other studies of coat color, such as those made in the Shorthorns. In the study of the roan coat of this breed about the only thing which the results of Wilson (*49–56*), Laughlin (*19*), Wentworth (*44, 45*), Barrington and Pearson (*6*), and Walther (*43*) have in common, are exceptions which each found to the interpretations offered by the other writers. A beginning at a solution of these exceptions has been made by the excellent review of the writings of Storer, Wilsdorf, and others on white body color by Lloyd-Jones and Evvard (*20*). In this review they show that two types of identical white body with colored ears exist. In the Chillingham cattle this white is dominant. In the Highland cattle it is recessive.

This does not quite fit the case of the roan Shorthorn, for, while the presence of these two genetically different whites would complicate the

results, it is entirely likely that their presence would be noted because the pattern of each is so striking. It does remain to be shown rather that the piebald cattle, like the Shorthorn, have a difference in behavior of the separate spots which compose this piebald. A beginning at this kind of analysis has been made by Kiesel, according to a review by Lang (*18*). In these experiments a solid-color Limburger race was crossed to a piebald race, F_1 intermediate piebald. The back cross gave 22 solid color and 29 piebald. The back cross to the piebald gave 84 piebald out of 90. Unfortunately, no record of the exact spotting has been given; consequently, we are left in the dark concerning any difference in behavior throughout the coat. It would seem, however, that Kiesel's results would fall in line with the results obtained here, where each individual area is treated separately.

Analysis by the method of individual white spots has shown a marked difference in the inheritance of such spots throughout the animal's coat. This is perhaps as far as the writer should go, and is the only conclusion it is intended to emphasize; but realizing that there are exceptions not yet accounted for, it may be said that white spotting in the inguinal region is, broadly speaking, dominant. The spots of the rest of the piebald pattern are, individually considered, recessive. These enumerated individually according to the region in which they occur are (1) white on the face (star, star snip, or blaze); (2) white on the throat; (3) white as a band across the shoulders; (4) a white area on the rump at the base of the tail set; (5) white on the flanks as irregular spots; (6) white on the tail above the switch; and (7) the white stockings on the four feet.

The bearing of this difference in inherited behavior on the general problem is at once evident. If the red-coated Shorthorns should carry one of these recessive white spots, we should expect a small proportion of cattle produced from the random mating of such an animal in the Shorthorn population which would be white-spotted. In point of fact, this is what has actually been obtained. The reverse is also true that if these dominant white are mated together, we should expect that a heterozygous mating would now and then take place, giving a red. The evidence brought forward offers a straightforward, clear explanation of the anomolous behavior of the Shorthorn coat.

Behavior of the Muzzle Color in the F_1 Progeny

The categories used to describe the color of the muzzle pigment are, in general, the same as those used for the tongue color. The tabulation and classification of these terms has already been given by Pearl (*33*). For this classification the reader is referred to his paper. In his study of tongue color it was found that the essential thing was not so much the color of the pigment but rather its presence. This study will, therefore, be limited to the presence or absence of pigment. Table XXIII gives the tabulated data for this treatment.

TABLE XXIII.—*Behavior of the muzzle pigment in the parental and first filial generations*

Sire.	Description of mating.	Offspring.
Taurus Creamelle Hengerveld.	White×pigmented	13 pigmented.
Do	White × F_1, pigmented carrying white.	1 white with small black spots.
Kayan	Pigmented×pigmented	13 pigmented.
Do	Pigmented×white	3 pigmented.
Do	Pigmented×pigmented and white	Do.
Do	Pigmented×white, few pigmented spots.	1 pigmented.
Lakeland's Poet	Pigmented×pigmented	5 pigmented.
Do	Pigmented×pigmented, spotted	1 pigmented.
Minor crosses:		
Crossbred 9	F_1 pigmented carrying white×pigmented.	2 pigmented.
Do	F_1 pigmented carrying white×pigmented carrying white.	3 pigmented.
Crossbred 10	Pigmented carrying white×white, few black spots.	1 smoky brown.
Lady Primrose's Governor of the Fountain.	White×pigmented	1 pigmented.

The conclusion to be drawn from Table XXIII is that the pigmented muzzle is dominant to the nonpigmented one.

BEHAVIOR OF THE TONGUE PIGMENT IN THE F_1 OFFSPRING

The inheritance of tongue color in cattle has already been studied in this laboratory. The previous study on several thousand cattle indicates that pigmentation is due to two closely coupled factors. The data here are not sufficient to test this hypothesis thoroughly. As far as it goes, Table XXIV substantiates the previous conclusions.

TABLE XXIV.—*Behavior of the tongue pigment in the parental and first filial generation*

Sire.	Description of mating.	Offspring.
Taurus Creamelle Hengerveld.	White×pigmented	6 pigmented, 1 black and white.
Do	White×white	1 white.
Do	White×F_1 white	2 white.
Kayan	Pigmented×pigmented	6 pigmented.
Do	Pigmented×white	10 pigmented, 3 black and white.
Lakeland's Poet	Pigmented×pigmented	3 pigmented.
Do	Pigmented×white	2 white, 1 pigmented.
Minor crosses:		
Crossbred 9	Pigmented carrying white × pigmented.	2 pigmented.
Do	Pigmented carrying white × pigmented carrying white.	2 white.
Do	Pigmented carrying white×white	1 white.
Crossbred 10	F_1 pigmented carrying white×white	Do.
Lady Primrose's Governor of the Fountain.	White×pigmented	1 pigmented.
Columbia's Fox	Pigmented×pigmented	Do.

Pigmented is dominant to unpigmented tongue. Lakeland's Poet seems to contradict this but a study of his pedigree given above shows him heterozygous for the unpigmented tongue.

Inheritance of Switch Color

All of the crosses available for study in this experiment have either one or both of the parents with a black switch. It is impossible, therefore, to determine the dominance of the other colors to each other. Black as a color is dominant to the other colors (Table XXV).

Table XXV.—*Behavior of the switch color in the parental and first filial generations*

Sire.	Description of mating.	Offspring.
Taurus Creamelle Hengerveld.	White×black	1 black, 2 white, 2 black and white.
Do	White×white	2 white, 1 white with few black hairs.
Do	White×black, few gray hairs.	2 white, 1 white tip and 1 black.
Do	White×F_1 white	2 white.
Kayan	Black, few white hairs×black.	5 black.
Do	Black, few white hairs×white.	10 black, 1 black×white.
Do	Black, few white hairs×mixed red, black, gray.	3 black.
Lakeland's Poet	Black×white	1 black, 1 black×white, 1 black, few white hairs.
Do	Black×black, few white hairs.	3 black.
Minor crosses:		
Crossbred 0	Black carrying white×black.	2 black.
Do	Black carrying white×black carrying white.	1 white.
Do	Black carrying white×black and white.	Do.
Do	Black carrying white×white.	1 black.
Crossbred 10	....do	1 red.
Lady Primrose's Governor of the Fountain.	White×black, few white hairs.	1 black.
Johanna Lad Manor De Kol.	White×brown	1 black and white.
Columbia's Fox	Black×black, few white hairs.	1 black.

The apparent exceptions to this conclusion are shown by their pedigrees and their other breeding records to be heterozygous for the white factor.

Two interesting cases of segregation appear in the F_2 generation. A white switch resulted from mating Crossbred 0 (black carrying white) to an F_2 cow (black carrying white). Another case of segregation of perhaps more interest than the above is that from Crossbred 10 (black carrying white × white). This mating gave an orange-red—that is, the ground color of the Guernsey minus its diluting factor has been substituted for the white of the parent.

SEGREGATION OF THE POLLED CHARACTER

In his interesting review of the literature on domestic cattle and their origin Morse (*25*) and others (*5*) give briefly the theories as to hornless cattle (*47*). The different views held all go back to the conception of use in selection to account for the loss of horns. Durst (*14*) and Ewart (*15*) take the ground that domestication has brought about the loss of horns.

Auld (*4*) considers that a reduction in the horns took place in between the upper Eocene and lower Miocene period. Contradictory to this, Arenander (*2*) says the first cattle were hornless. Major (*23*) found skulls in the tertiary deposits in Italy the males of which were horned and the females hornless. Thus he considers a progressive extension of this would bring about the hornless race. This is something of the idea of Keller (*16*), when he cites the African cattle with movable horns to be ancestors of the hornless animals.

Based on rough notes collected at the Smithfield Club, Bateson and Saunders (*7*, *8*) treated these data on the horned character in cattle as if it were a single Mendelian factor and conclude that the presence and absence of horns are almost certainly allelomorphic characters. Further data collected by Spillman (*41*) on 165 cases led him to conclude that polledness is a simple Mendelian dominant. Boyd (*10*) has given later data on polledness in his cross of mutant polled Herefords onto pure horned Herefords and in his crosses of polled cows to the American bison. In both of these the polled character is dominant. In one of his bulls, Variation, he thinks he gets a significant difference from the expected ratio of 1 to 1. Thus, in crosses of Variation with pure horned cows he obtains 22 polled to 6 horned, or a difference from the expected 14 to 14 of 3.1 times the probable error of the theoretical half, or what might seem a significant difference. Lloyd-Jones and Evvard (*20*) have added materially to the data already presented. In 71 matings of Shorthorn bulls to Galloway cows 70 were clear-polled, 6 scurred, and 2 horned. This would seem to indicate that the polled factor is dominant. By this view the two horned heifers are exceptions to this conclusion. On this point, however, it seems well to quote them, as it appears to the author that the explanation they offer is correct. In reference to the dams of these horned heifers, they say (*20*, *p. 100a*):

> The cows 154 and 49 are referred to as "pure-bred Galloway," but their behavior in respect to the transmission of horns is not in harmony with what we should be justified in expecting if this were the case. Of all the polled breeds of cattle the Galloways have been longest established and, in the matter of horns perhaps the most rigidly selected, and they are recognized as practically never producing horned offspring. On the other hand, it must be pointed out that there does not exist an inevitable incompatibility between the heterozygous condition for polled, on the one hand, and the "pure-bred" condition, on the other. To be pure bred, from the breeders' standpoint, an animal must be recorded in the record books of the breed associations, or eligible for such record, or it must be from parents whose recent ancestors were thus recorded or eligible to record. To be sure, horned Galloways are not eligible to record, but the herd-book associations make no biological restrictions as to the

animal carrying horns recessive, and polled Galloway cows may not be disqualified as pure-breds because they happen to produce horned offspring. Therefore, although the behavior of the Galloway cows Nos. 154 and 49, one-half of whose offspring by a P_p bull have been horned, is "not in harmony with what we would expect" if they were pure-bred animals, nevertheless, it does not serve as conclusive evidence that they are not such. But if these two cows were *bona fide* pure-bred Galloways it is at least plain that we can not rely upon pedigree and registration as assurance that animals, purchased as pure-breds, are homozygous for the polled trait.

Thus, in the opinion of these authors the occurrence of horns on the heifers were due to their female parents being heterozygous for the horned factor.

In this same paper data on the segregation of polledness are given. In back crosses of P′p×pp (where P′ is the polled and p the horned factor) 7 polled to 9 horned were obtained where the expectation was 8 to 8. In P′p×P′p matings 20 polled to 8 horned were obtained where the expectation was 21 to 7. Their conclusion (*20, p. 102a*) on this evidence would seem substantiated:

> The present results substantiate the allelomorphic nature of the horned and polled condition in cattle.

The citations seem to prove conclusively that polledness is a simple Mendelian character. Some exceptions to this conclusion in our crosses, the results of which are presented in Table XXVI, gave ground for the belief that other factors influenced the result.

TABLE XXVI.—*Behavior of the polled character in the parental and first filial generations*

Sire.	Description of mating.	Offspring.
Taurus Creamelle Hengerveld.	Horns × horns	10 horns.
Do	Horns × polled	2 polled (1 ♀, 1 ♂), 2 loose scurs (1 ♀, 1 ♂).
Do	Horns × F_1 horns	1 horned.
Kayan	Polled × horns	8 polled (7 ♀, 1 ♂, slight prominence not through skin). 6 loose scurs (6 ♂). 3 tight scurs (3 ♂). 1 heavy horn (1 ♂).
Lakeland's Poet	Horns × horns	3 horns.
Do	Horns × polled	2 polled (2 ♀), 1 horned (♂).
Minor crosses:		
Crossbred 0	Horns × horns	5 horns.
Crossbred 10	Polled carrying horns × horns.	1 horned.
Johanna Lad Manor De Kol	Horns × horns	Do.

On the above interpretation, the data in Table XXVI offer several interesting anomalies. The first is an animal resulting from a mating of Kayan to the Ayrshire cow Dot Alaska. This mating produced a male, No. 21, with heavy 4-inch solidly attached horns (Pl. 6, B). By his previous breeding record, where each mating constituted a back cross,

it would seem that Kayan has been shown homozygous for the polled character, for if Kayan is considered heterozygous for the polled character, we have the impossible ratio of 17 polled to 1 horned, where the expectation is equality. Another assumption is left open: The scurred animals are really homozygous for the horned factor. This hypothesis seems unlikely on the following grounds: Scurs are present only where polled individuals are also in the stock. The inclusion of the scurred animals with the polled ones always improves back-cross ratios of polled × horned crosses, whereas the inclusion of scurred individuals with the horned group makes the ratios far from probable.

The same kind of case occurs in No. 31 out of the Aberdeen-Angus cow Eventime 4th. Since it has not been possible to test her genetic composition in so thorough a manner as that of Kayan, the case may be due to Eventime 4th being heterozygous for the horned factor.

Thus, we have two exceptional cases for polledness which demand a supplementary hypothesis to explain their appearance.

Spillman (*41*) says that scurs may develop to considerable size, but are loose and hollow. It is interesting in this connection, however, to point out that 8 loose- to 3 tight-scurred animals occur, a ratio corresponding well with the expectation of the F_2 population for a separate factor for loose and tight scurs. From this the most probable explanation would seem to be that loose and tight scurs are due to a simple Mendelian factor and not due to any inherent quality of being scurs.

In another paragraph in the same paper Spillman says that males are more likely than females to have scurs. This statement, however, is not supported by evidence, and in fact is contradicted by Lloyd-Jones and Evvard (*20*), who say their data—

> give no evidence that sex is in any way connected with the inheritance of these characters [Horned and polledness].

These investigators offer numerical data on the frequency of scurs. In 78 cases 6 were scurred and 2 horned. It will be seen that this frequency is much below that of the data of the author. Unfortunately Lloyd-Jones and Evvard do not sex their data; but it is possible to group the data of the present author in relation to sex, as is seen in Table XXVII.

TABLE XXVII.—*Relation of sex to polledness* [a]

Description of mating.		Polled.		Scurred.				Horned.	
Sire.	Dam.	Male.	Female.	Solid attachment.		Loose attachment.		Male.	Female.
				Male.	Female.	Male.	Female.		
Horned.....	Polled.....	1	3	.....	.....	1	1	1	.....
Polled.....	Horned.....	[b] 1?	7	3	.....	6	.....	1	.....

[a] This table is based on descriptions made before any idea of the influence of testicular secretion on the production of horns in the heterozygous individual was thought of.

[b] This male is recorded with loose scurs just under skin. He died and was put away before this could be checked.

The polled character in these crosses occurs most frequently in the females. In 7 offspring from matings of horned males with polled females, 3 polled females were produced to 1 polled male; 1 male and 1 female had scurs and 1 male had heavy horns. In the reciprocal cross of polled male bred with horned female, 1 male was doubtfully recorded as "loose scurs under the skin." He died before this could be checked. Of the others, 7 females were polled, 3 males had solidly attached scurs, 6 had loose scurs, and 1 was horned.

These data make it probable that sex has some influence on the horned condition. The parallel with the case of sheep is of special interest, for castration experiments by Wood and others (*57*) have established the presence of a secretion by the testis which materially aids the production of horns in this species. On the basis of this the testis in the bull would be expected to secrete a hormone which would produce horns with one dose of the horned genes, where two doses of the horned gene would be required by the female.

The parallel is still further emphasized by the variability, both intra- and inter-racially of the action of this secretion or hormone. Thus, Crossbred 9 (Pl. 4, A) at three years had scurs only, whereas Crossbred 21 at one year had heavy horns. For the case of sheep the work of Arkell and Davenport (*3*) have shown a similar length of time necessary for the action of the secretion in this species (*see also 13*).

This variability in the action may be the explanation of the results obtained by Lloyd-Jones and Evvard (*20*), where, out of 78 offspring of a Shorthorn bull to Galloway cows, they obtained only 6 scurred and 2 horned animals (see p. 45). Here it is conceivable that in this cross the secretion may be small in amount or lacking as in some of the merinos that Arkell bred. Such a lowered concentration or amount of the secretion would explain the results, as without its aid to the growth of horns the male offspring would be polled like the female, and the results obtained by Lloyd-Jones and Evvard would be expected. This difference in the behavior within a species is still further emphasized by the work of Morgan (*24*) on the hen-feathered races of poultry. In this case the hen-feathered character is known to vary all the way between a strictly hen-feathered male to one of almost complete cock plumage. This variability may also take place in the same bird of the Campine race owing to age or to a difference in the physiological state of the bird.

The position of cattle in the series of animals known to possess such a secretion seems intermediate between that of reindeer and sheep, since castration experiments on the horned breeds show no retarding of the horn growth, although it does tend to make the horn longer and more slender.

ON THE BEEF QUALITIES OF THE F_1 OFFSPRING

The qualities of an animal which make for the beef or dairy form seem to be divisible into four general regions when considered from the hereditary point of view. These regions from front to back are head, fore quarters, barrel, and hind quarters. It seems wise to have fairly broad categories under which to group the qualities of beef or milk production. In view of this the descriptive terms chosen to describe these animals are beef, beef and milk, milk and beef, and milk. Tables XXVIII shows the characters so grouped.

TABLE XXVIII.—*Behavior of the type of head, fore and hind quarters, and barrel, in the parental and first filial generation*

HEAD

Sire.	Description of mating.	Offspring.
Taurus Creamelle Hengerveld.	Milk × beef	3 beef and milk, 1 milk and beef.
Do	Milk × milk	10 milk.
Kayan	Beef × milk	4 beef, 14 beef and milk, 2 milk and beef.
Lakeland's Poet	Milk × beef	2 beef and milk, 1 milk and beef.
Do	Milk × milk	1 milk and beef, 2 milk.
Minor crosses:		
Crossbred 9	do	5 milk.
Crossbred 10	Beef and milk × milk	1 milk and beef.
Lady Primrose's Governor of the Fountain.	Milk × beef	Do.
Johanna Lad Manor De Kol	Milk × milk	1 milk.
Columbia's Fox	Milk × beef	1 beef and milk.

FORE QUARTERS

Taurus Creamelle Hengerveld.	Milk × beef	3 beef and milk, 1 milk and beef.
Do	Milk × milk and beef	1 milk and beef.
Do	Milk × milk	8 milk.
Kayan	Beef × milk	6 beef, 14 beef and milk.
Lakeland's Poet	Milk × beef	3 beef and milk.
Do	Milk × milk and beef	2 milk and beef, 1 milk.
Minor crosses:		
Crossbred 9	Milk × milk	5 milk.
Crossbred 10	Beef and milk × milk	1 milk and beef.
Lady Primrose's Governor of the Fountain.	Milk × beef	1 beef and milk.
Johanna Lad Manor De Kol	Milk × milk	1 milk.
Columbia's Fox	Milk × beef	1 beef and milk.

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TABLE XXVIII.—*Behavior of the type of head, fore and hind quarters, and barrel, in the parental and first filial generation*

BARREL

Sire.	Description of mating.	Offspring.
Taurus Creamelle Hengerveld.	Milk × beef	4 milk and beef.
Do	Milk × milk and beef	1 milk.
Do	Milk × milk	6 milk.
Kayan	Beef × milk and beef	1 beef and milk, 1 milk and beef.
Do	Beef × milk	1 beef, 5 beef and milk, 11 milk and beef.
Lakeland's Poet	Milk × beef	3 milk and beef.
Do	Milk × milk and beef	1 milk.
Do	Milk × milk	1 milk and beef, 1 milk.
Minor crosses:		
Crossbred 9	do	5 milk.
Crossbred 10	Beef and milk × milk	1 milk.
Lady Primrose's Governor of the Fountain.	Milk × beef	1 milk and beef.
Johanna Lad Manor De Kol	Milk × milk	1 milk.
Columbia's Fox	Milk × beef	1 beef and milk.

HIND QUARTERS

Taurus Creamelle Hengerveld.	Milk × beef	4 milk and beef.
Do	Milk × milk and beef	1 milk.
Do	Milk × milk	8 milk.
Kayan	Beef × milk and beef	1 beef and milk, 1 milk and beef.
Do	Beef × milk	1 beef, 6 beef and milk, 11 milk and beef.
Lakeland's Poet	Milk × beef	3 milk and beef.
Do	Milk × milk and beef	1 milk and beef, 2 milk.
Minor crosses:		
Crossbred 9	Milk × milk	5 milk.
Crossbred 10	$\left\{\begin{matrix}\text{Beef}\\ \text{Milk}\end{matrix}\right.$ × milk	1 milk.
Lady Primrose's Governor of the Fountain.	Milk × beef	1 milk and beef.
Johanna Lad Manor De Kol	Milk × milk	1 milk.
Columbia's Fox	Milk × beef	1 beef and milk.

The dairy and beef qualities are seen to be blended to a considerable extent in the F_1 offspring. Even with this blending, however, dominance and recessiveness may be discerned in the crosses. The beef qualities are, in general, quite pronounced in the head and fore quarters of these hydrids. The dairy qualities seem to predominate in the barrel and hind quarters. This conclusion is further supported by a study of some exact measurements taken in various parts of the body of these animals. While the number of cows having these measurements is relatively small, they do show several interesting points. Taken without regard for their probable errors, the head of crossbreds with Angus blood is somewhat shorter in length and broader between the eyes than crossbreds of the dairy breeds of the same age. The girth at the last

rib for these Angus crossbreds is increased, as is also the width of the brisket. The measurements of the hind parts of the body show there is no change from the general form of the other crossbreds other than a slight shortening of the rump.

This conclusion is not in entire agreement with the few known recorded crosses where descriptions are given. Bruce (*12*) records crosses resulting from Dexter cattle with Shorthorns as wonderful beef animals. Boyd (*10*) says of his wide crosses of bisons with domestic cattle that the following characters are dominant: A somewhat modified hump of the bison, width of hind quarter, and width in front of the beef breeds. Nabours (*26*), describing the crosses made by Borden (*9*) of *Bos indicus* on *Bos taurus* says a modified hump, great increase in body size, and dewlap are characteristic of the F_1 progeny. The heavy filling in front is characteristic for all of these crosses. Bruce and Boyd, however, record an increase in the size and quality of the hind quarters. The author finds no such increase in his crosses.

From his results the author may say that for the improvement of the beef qualities of dairy breeds the first-generation crosses result in an increased value of the beef qualities in the fore quarters without materially influencing the hind quarters.

MILKING QUALITY OF THE F_1 OFFSPRING

Since the results on the milking qualities of the F_1 offspring are of interest, as they are new, it seems well to add them to this study, although they are as yet few in number. Tables XXIX and XXX give the age, days in milk, production, and the production expected from these animals when they reach their maximum at mature form. By forming a column for the difference in excess of the parent over that of the offspring it is possible to compare their productions and clearly bring out the differences. This same method may also be used for both fat and fat percentage. Tables XXIX and XXX give the results of such treatment. The quantity and the quality of the milk are separately treated, as it has been shown by Wilson (*49–56*), Pearson (*39*), and others (*40*), that the quality bears little relation to the quantity of the milk flow.

TABLE XXIX.—*Transmission of milk production from parental to first filial generation*

	Production of daughter.				Production of dam.				Difference daughter-dam production.
Mating.	Age.	Days in milk.	Production.	Correct maximum for 100 days.	Age.	Days in milk.	Production.	Correct maximum for 100 days.	
	Yr. m. d.		*Pounds.*	*Pounds.*	*Yr. m. d.*		*Pounds.*	*Pounds.*	*Pounds.*
101.....	2 0 5	110	2,016	2,666	10 8 14	104	3,579	3,600	− 934
102.....	2 7 26	105	3,035	3,849	3 9 5	96	2,243	2,846	+1,004
111.....	2 3 22	110	2,334	2,791	5 4 28	113	3,168	2,086	+ 105
112.....	2 4 7	93	2,312	3,405	4 4 5	109	1,830	1,881	+1,524

TABLE XXX.—*Transmission of fat concentration from parental to first filial generation*

Mating.	Production of daughter.				Production of dam.				Difference daughter-dam production.
	Age.	Days in milk.	Fat.	Correct maximum for 100 days.	Age.	Days in milk.	Fat.	Correct maximum for 100 days.	
	Yr. m. d.		*Per cent.*	*Per cent.*	*Yr. m. d.*		*Per cent.*	*Per cent.*	*Per cent.*
101.....	2 0 5	110	4.4	494	10 8 14	104	2.5	2.7	+1.7
102.....	2 7 26	105	3.2	392	3 9 5	96	3.4	3.5	− .3
111.....	2 3 22	110	3.2	3.2	5 4 28	123	3.6	3.8	− .6
112.....	2 4 7	93	3.5	3.5	4 4 5	109	5.4	5.6	−2.1

Tables XXIX and XXX show that high milk production tends to behave as dominant—that is, in a cross of high-producing lines to low-producing lines the offspring tends to have the high production of the high line. This agrees well with some unpublished studies on a large series where the productions of both parental lines are known.

Unfortunately a like result can not be said for percentage of fat. Here the parental high fat percentage is suppressed in the offspring when this parent is crossed to a low line.

SUMMARY

This constitutes a preliminary paper on the crossbred herd now being brought together by the Maine Agricultural Experiment Station for the purpose of studying some of the outstanding problems of dairy husbandry.

The first section of the paper is devoted to a study of the inbreeding in the foundation herd. It is shown that the inbreeding as measured by the best mathematical methods is no greater than would be expected to occur in any of the modern breeds when the animals were selected at random. Consequently it is safe to assume that the results of the study are not due to the width of the crosses, for, as has been pointed out, a number of the animals famous in their breed have been far more inbred than any of the parental stock used in these experiments.

The individual records of the animals composing both the parental generation and the first and second filial generations are given.

(1) Black body color is dominant to the other color in the first generation. In the second generation an orange-coated bull and a dark Jersey dun-coated heifer were segregated out. This is to be explained on the basis of a recessive dilutor in the Guernsey, segregated out along with the black color. The dark heifer shows that the Jersey does not normally possess this factor.

(2) It has been shown that white marking of the body taken as a whole appears as a dominant. Study of the individual white areas, however, indicate that this is due to white in the inguinal region only, for this

alone appears as such a dominant. The white spots on the face (star, star snip, and blaze), neck, shoulders, rump, flanks, and legs are, in general, suppressed in their offspring when such animals are mated to solid color.

(3) As has been suggested, but as has never been tested before, the pigmented muzzle is dominant to the one not so pigmented.

(4) Agreeing with the previous work of this laboratory it is shown that a pigmented tongue is dominant to a nonpigmented one.

(5) A black switch appears to cause the suppression of the other switch colors in the offspring. Because of this suppression and because all of the matings had at least one animal with a black switch as parent, it was impossible to study the behavior of the other colors. There was one case of segregation of a deep red-orange switch from a back cross of a black animal carrying an orange coat and white switch, genetically. This case showed the segregation of the factor for orange switch from that for both white and black.

(6) The character of polledness has been studied. Two-horned animals resulting from crosses of polled × horned appeared. On the basis of the other results these could have not resulted from a heterozygous polled condition. One of these cases had the horns tight on the head and the other loose. These cases then form exceptions to the previously accepted hypothesis of simple dominance for the polled character and require a subsidiary hypothesis. The hypothesis suggested is that the testes have some action on the presence or absence of horns. Partial proof to this hypothesis is given by the fact that of the polled animals 10 were females, 2 males, 1 doubtfully polled. Of those with scurs 1 female and 7 males had loose scurs; of those with tight scurs all (3) were males; of those with horns all (2) were males. This would seem like a clear case where the male has some influence. The explanation of this difference appears to be due to a hormone secreted by the germ cells. Should this prove true, this forms an interesting parallel between cattle and sheep, in which the sex glands are known to produce such changes.

(7) The qualities of beef production are shown to be divisible into four general regions of the body: head, fore quarters, barrel, and hind quarters. The type of head and heavy, deep fleshed fore quarters are transmitted to the offspring when either parent is of Aberdeen-Angus breed. The body and hind quarters appear intermediate, but resemble most the dairy parents.

(8) Data are given on the milk and fat production of some of the crossbreds. The results indicate that milk and fat production behave separately. High milk production is dominant to low, but high fat percentage is recessive to a low fat percentage in the milk.

LITERATURE CITED

(1) ALLEN, G. M.
1914. PATTERN DEVELOPMENT IN MAMMALS AND BIRDS. *In* Amer. Nat., v. 48, no. 571, p. 385–412, fig. 1–42; no. 572, p. 467–484, fig. 42a–57; no. 573, p. 550–566, fig. 58–62. References, p. 564–566.

(2) ARENANDER, E. D.
1898. STUDIEN ÜBER DAS UNGEHÖRNTE RINDVIEH IM NÖRDLICHEN EUROPA UNTER BESONDERER BERÜCKSICHTIGUNG DER NORDSCHWEDISCHEN FJELLRASSE, NEBST UNTERSUCHUNGEN ÜBER DIE URSACHEN DER HORNLOSIGKEIT. *In* Ber. Physiol. Lab. Vers. Anst. Landw. Inst. Univ. Halle, Bd. 3, Heft 13, p. 43–184, 7 pl.

(3) ARKELL, T. R., and DAVENPORT, C. B.
1912. THE NATURE OF THE INHERITANCE OF HORNS IN SHEEP. *In* Sci., n. s. v. 35, no. 911, p. 927.

(4) AULD, R. C.
1887. HORNLESS RUMINANTS. *In* Amer. Nat., v. 21, no. 8, p. 730–746, fig. 1–4, pl. 25; no. 10, p. 885–902, fig. 5–18; no. 12, p. 1076–1098, fig. 19. pl. 35. (Continued.)

(5) B., L. N.
1909. ORIGIN OF POLLED DURHAMS. *In* Breeders' Gaz., v. 55, no. 7, p. 380.

(6) BARRINGTON, A., and PEARSON, Karl.
1906. ON THE INHERITANCE OF COAT COLOR IN CATTLE. *In* Biometrika, v. 4, pt. 4, p. 427–464.

(7) BATESON, William.
1909. MENDEL'S PRINCIPLES OF HEREDITY. 396 p., illus., 6 col. pl. Cambridge, Eng. Bibliography, p. 369–384. Supplementary list, p. 385.

(8) ——— and SAUNDERS, Edith R.
1901. EXPERIMENTAL STUDIES IN THE PHYSIOLOGY OF HEREDITY. Roy. Soc. [London], Rpts. Evol. Com., no. 1, 160 p.

(9) BORDEN, A. P.
1910. INDIAN CATTLE IN THE UNITED STATES. *In* Amer. Breeders' Mag., v. 1, no. 2, p. 91–94, illus.

(10) BOYD, M. M.
1906. BREEDING OF POLLED HEREFORDS. *In* Amer. Breeders' Assoc. Proc., v. 2, p. 198–201.

(11) BREWER, W. H.
1882. ON THE DISPOSITION OF COLOR-MARKINGS ON DOMESTIC ANIMALS. *In* Proc. Amer. Assoc. Adv. Sci., v. 30, 1881, p. 246–251.

(12) BRUCE, Robert.
1909. THE DEXTER CATTLE. *In* Breeders' Gaz., v. 56, no. 18, p. 887.

(13) CASTLE, W. E.
1912. ARE HORNS IN SHEEP A SEX-LIMITED CHARACTER. *In* Science, n. s. v. 35, no. 902, p. 574–575.

(14) DURST, J. U.
1899. DIE RINDER VON BABYLON ASSYRIEN UND AGYPTEIN UND IHR ZUSAMMENHANG MIT DEN RINDERN DER ALTEN WELT. 94 p. Berlin.

(15) EWART, J. C.
1909. HORNLESS CATTLE. *In* Live Stock Jour., v. 70, no. 1861, p. 599–600.

(16) KELLER, C.
1897. DIE AFRIKANISCHEN ELEMENTE IN DER EUROPÄISCHEN HAUSTIERWELT. *In* Globus, Bd. 72, no. 18, p. 285–289.

(17) KUHLMAN, A. H.
1915. JERSEY-ANGUS CATTLE. *In* Jour. Hered., v. 6, no. 2, p. 68–72, illus.

(18) LANG, Arnold.
1914. EXPERIMENTELLE VERERBUNGSLEHRE IN DER ZOOLOGIE SEIT 1900. Hälfte 1. Jena.
Review of work by Kiesel, p. 849–851.

(19) LAUGHLIN, H. H.
1911. THE INHERITANCE OF COLOR IN SHORT-HORN CATTLE. *In* Amer. Nat., v. 45, no. 540, p. 705–742, 9 fig.

(20) LLOYD-JONES, Orren, and EVVARD, J. M.
1916. INHERITANCE OF COLOR AND HORNS IN BLUE-GREY CATTLE. Iowa Agr. Exp. Sta. Research Bul. 30, p. 67a–106a, 10 fig. Bibliography, p. 106a.
Cites works of Storer and Wilsdorf.

(21) MCCURDY, Hansford, and CASTLE, W. E.
1907. SELECTION AND CROSS-BREEDING IN RELATION TO THE INHERITANCE OF COAT-PIGMENTS AND COAT-PATTERNS IN RATS AND GUINEA-PIGS. 50 p., 5 fig., 2 pl. Washington, D. C. (Carnegie Inst. Washington, Pub. 70.)

(22) MACDONALD, James, and SINCLAIR, James.
1910. HISTORY OF ABERDEEN-ANGUS CATTLE. Rev. ed. 682 p., pl. London.

(23) MAJOR, C. J. F.
1885. ON THE MAMMALIAN FAUNA OF THE VAL D'ARNO. *In* Quart. Jour. Geol. Soc. London, v. 41, p. 1–8.

(24) MORGAN, T. H.
1917. THE THEORY OF THE GENE. *In* Amer. Nat., v. 51, no. 609, p. 513–544, 9 fig.

(25) MORSE, E. W.
1912. THE ANCESTRY OF DOMESTICATED CATTLE. *In* U. S. Dept. Agr. Bur. Anim. Indus. 24th Ann. Rpt. 1910, p. 187–239, 16 fig., pl. 13–15. Bibliography, p. 233–239.

(26) NABOURS, R. K.
1912. EVIDENCE OF ALTERNATIVE INHERITANCE IN THE F_2 GENERATION FROM CROSSES OF BOS INDICUS ON BOS TAURUS. *In* Amer. Nat., v. 46, no. 547, p. 428–436, 9 fig.

(27) PEARL, Raymond.
1913. CONSTANTS FOR NORMAL VARIATION IN THE FAT CONTENT OF MIXED MILK. Maine Agr. Exp. Sta. Bul. 221, p. 299–305.

(28) ———
1913. A CONTRIBUTION TOWARD AN ANALYSIS OF THE PROBLEM OF INBREEDING. *In* Amer. Nat., v. 47, no. 562, p. 577–614, 2 fig.

(29) ———
1914. ON THE LAW RELATING MILK FLOW TO AGE IN DAIRY CATTLE. *In* Proc. Soc. Exp. Biol. and Med., v. 12, no. 1, p. 18–19.

(30) ———
1914. ON THE RESULTS OF INBREEDING A MENDELIAN POPULATION. *In* Amer. Nat., v. 48, no. 565, p. 57–62.

(31) ———
1914. STUDIES ON INBREEDING. IV. ON A GENERAL FORMULA FOR THE CONSTITUTION OF THE N^{TH} GENERATION OF A MENDELIAN POPULATION IN WHICH ALL MATINGS ARE OF BROTHER × SISTER. *In* Amer. Nat., v. 48, no. 572, p. 491–494.

(32) ———
1914. STUDIES ON INBREEDING. V. INBREEDING AND RELATIONSHIP COEFFICIENTS. *In* Amer. Nat., v. 48, no. 573, p. 513–523, 2 fig.

(33) ———
1914. VARIATION IN THE TONGUE COLOR OF JERSEY CATTLE. *In* Proc. 34th Ann. Meeting Soc. Prom. Agr. Sci., 1913, p. 49–57.

(34) PEARL, Raymond.
1915. STUDIES ON INBREEDING. VI. SOME FURTHER CONSIDERATIONS REGARDING COUSIN AND RELATED KINDS OF MATING. *In* Amer. Nat., v. 49, no. 585, p. 570–575, 1 fig.

(35) ———
1917. STUDIES ON INBREEDING. VII. SOME FURTHER CONSIDERATIONS REGARDING THE MEASUREMENT AND NUMERICAL EXPRESSION OF DEGREES OF KINSHIP. *In* Amer. Nat., v. 51, no. 609, p. 545–559. 1 fig.

(36) ———
1917. STUDIES ON INBREEDING. VIII. A SINGLE NUMERICAL MEASURE OF THE TOTAL AMOUNT OF INBREEDING. *In* Amer. Nat., v. 51, no. 610, p. 636–639, 1 fig.

(37) ——— and MINER, J. R.
1913. TABLES FOR CALCULATING COEFFICIENTS OF INBREEDING. Maine Agr. Exp. Sta. Bul. 218, p. 191–202.

(38) ——— and PATTERSON, S. W.
1917. THE CHANGE OF MILK FLOW WITH AGE, AS DETERMINED FROM SEVEN DAY RECORDS OF JERSEY COWS. Maine Agr. Exp. Sta. Bul. 262, p. 145–152, fig. 7.

(39) PEARSON, Karl.
1910. NOTE ON THE SEPARATE INHERITANCE OF QUANTITY AND QUALITY IN COWS' MILK. *In* Biometrika, v. 7, pt. 4. p. 548–550.

(40) RIETZ, H. L.
1909. ON INHERITANCE IN THE PRODUCTION OF BUTTER FAT. *In* Biometrika, v. 7, pt. 1/2, p. 106–126.

(41) SPILLMAN, W. J.
1905. MENDEL'S LAW IN RELATION TO ANIMAL BREEDING. *In* Amer. Breeders' Assoc. Proc., v. 1, p. 171–177.

(42) WALLACE, Robert.
1889. FARM LIVE STOCK OF GREAT BRITAIN. 333 p., illus. Edinburgh.

(43) WALTHER, A. R.
1913. DIE VERERBUNG UNPIGMENTIERTER HAARE (SCHIMMELUNG) UND HAUSTELLEN ("ABZEICHEN") BEI KIND UND PFERD ALS BEISPIELE TRANSGRESSIV FLUKTUIERENDER FAKTOREN. *In* Ztschr. Abst. u. Vererb., Bd. 10, Heft 1/2, p. 1–48, 2 fig., 1 pl.

(44) WENTWORTH, E. N.
1912. SEGREGATION IN CATTLE. *In* Ann. Rept. Amer. Breeders' Assoc., v. 7/8, p. 572–580, 14 fig.

(45) ———
1913. COLOR IN SHORTHORN CATTLE. *In* Amer. Breeders' Mag., v. 4, no. 4, p. 202–208, illus.

(46) ———
1916. A SEX-LIMITED COLOR IN AYRSHIRE CATTLE. *In* Jour. Agr. Research, v. 6, no. 4, p. 141–147. Literature cited, p. 147.

(47) WILCKENS, M.
1876. DIE ABÄNDERNDEN EINFLÜSSE DER KULTUR AUF DIE FORM DES RINDERSCHÄDELS. *In* Landw. Jahrb., Bd. 5, p. 651–653.

(48) WILSDORF, Georg.
1912. TIERZÜCHTUNG. 110 p., 12 pl. Leipzig. Reviewed in Jour. Hered., v. 6, no. 3, p. 109–116.

(49) WILSON, James.
1908. TRANSMISSION OF COLOR IN SHORT-HORNS. *In* Breeders' Gaz., v. 54, no. 3, p. 86.

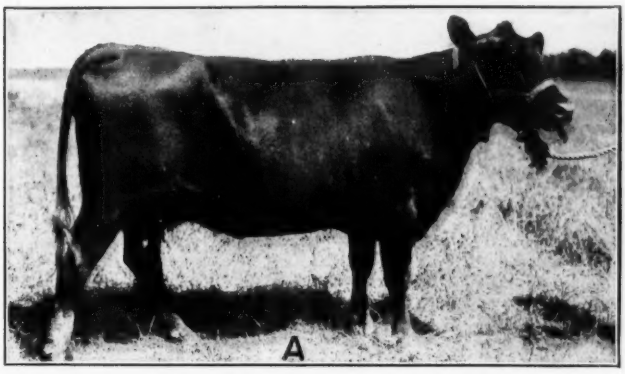
(50) WILSON, James.
1909. THE COLOURS OF HIGHLAND CATTLE. *In* Sci. Proc. Roy. Dublin Soc., n. s. v. 12, no. 8, p. 66–76, pl. 7
(51) ———
1909. EVOLUTION OF BRITISH CATTLE. 147 p., illus. London.
(52) ———
1909. THE SCANDINAVIAN ORIGIN OF THE HORNLESS CATTLE OF THE BRITISH ISLES. *In* Sci. Proc. Roy. Dublin Soc., n. s. v. 12, no. 15, p. 145–164, illus.
(53) ———
1910. THE SEPARATE INHERITANCE OF QUANTITY AND QUALITY IN COWS' MILK. *In* Sci. Proc. Roy. Dublin Soc., n. s. v. 12, no. 35, p. 470–479.
(54) ———
1911. THE INHERITANCE OF MILK-YIELDS IN CATTLE. *In* Sci. Proc. Roy. Dublin Soc., n. s. v. 13, no. 7, p. 89–112; no. 8, p. 113.
(55) ———
1914. POLYGAMOUS MENDELIAN FACTORS. *In* Sci. Proc. Roy. Dublin Soc., n. s. v. 14, no. 22, p. 302–312.
(56) ———
1916. A MANUAL OF MENDELISM. 152 p. London.
(57) WOOD, T. B.
1905. NOTE ON THE INHERITANCE OF HORNS AND FACE COLOUR IN SHEEP. *In* Jour. Agr. Sci., v. 1, pt. 3, p. 364–365, pl. 4.
(58) WRIGHT, Sewall.
1917. COLOR INHERITANCE IN MAMMALS. *In* Jour. Hered., v. 13, no. 11, p. 521–527.
(59) YOUATT, W.
1860. CATTLE . . . 469 p. New York.

PLATE 1

A.—Eventime 4th: This is a good Aberdeen-Angus cow of rather light fleshing. Note the size of the udder as compared with that of Hearthbloom. This cow produced 2,852 pounds of milk for the year, while Hearthbloom produced only 500.

B.—Hearthbloom: The rounded blocky conformation is typical of the Aberdeen-Angus breed. Notice the cleanly polled condition. This animal is of better beef type than Eventime 4th.

C.—Orono Netta: Note the typical horns thrown up well over the head. The large amount of white distributed over the coat between the red or brown areas is characteristic of the Ayrshire breed.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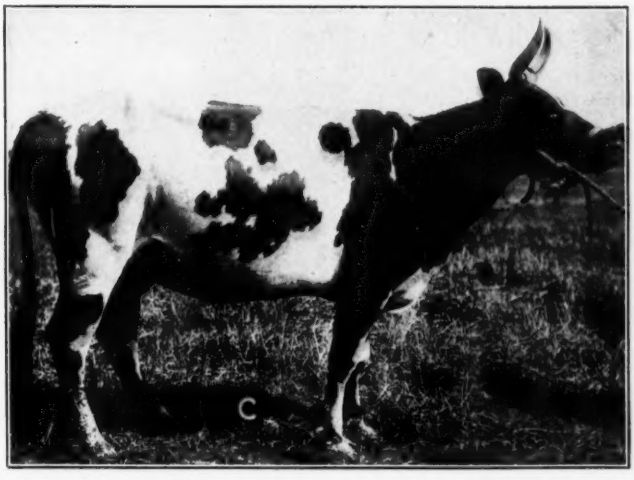
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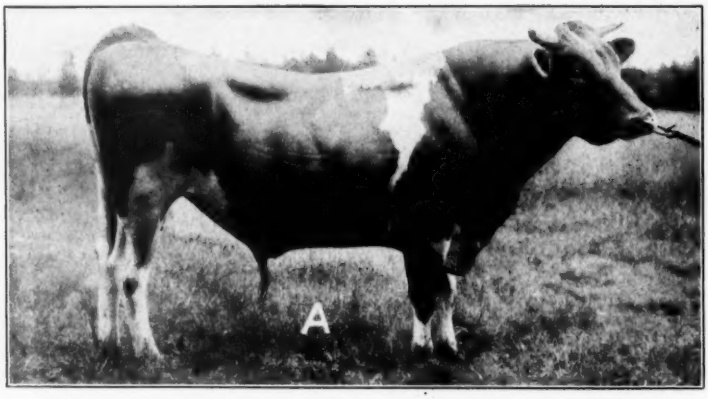
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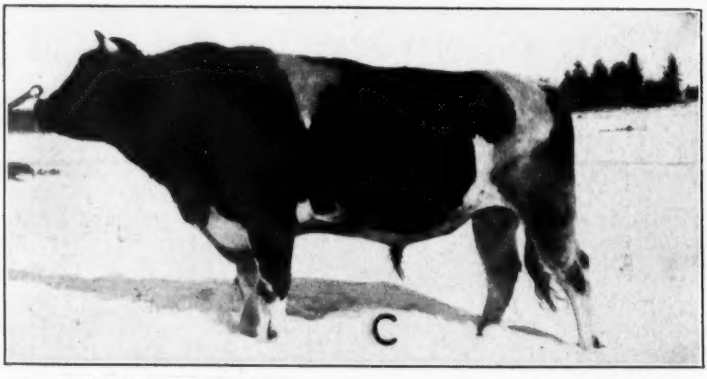
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PLATE 2

A.—Lady Primrose's Governor of the Fountain: This imported bull presents the characteristic conformation and white markings of the Guernsey breed. Notice the sag in the back and the high tail set.

B.—Creusa's Lady: The illustration of this Guernsey cow is inserted to show the large areas of white interspersed with the cream-colored hair typical of the coat of this breed. The presence of the star is quite characteristic.

C.—This Holstein-Friesian bull is of excellent constitution and vigor. He is the father of a good number of our crossbreds. Note that most of the white areas that are studied individually in this paper are present in this bull.

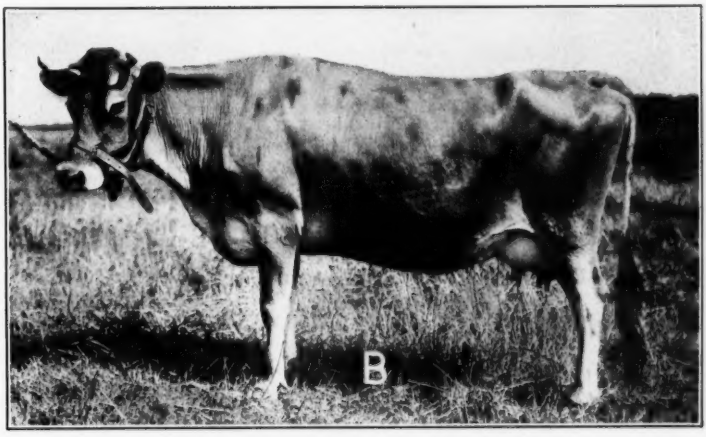
PLATE 3

A.—Lakeland's Poet: This Jersey bull exhibits the dark type of pigmentation at one end of the range of coat colors characteristic of the breed. He is at the opposite end of the range from Lassie of M. F., who shows the light type. He is the father of a number of the crossbreds now in the crossbred herd.

B.—Lassie of M. F.: The light pigmentation of the coat of this Jersey exhibits one end of the range of coat colors characteristic of the Jersey breed. The other extreme in pigmentation is shown by Lakeland's Poet (Pl. 3, A). The well-filled condition of the udder is typical of this Jersey.

C.—Crossbred 6: The characteristic shape of the head and carriage of horns show plainly the Ayrshire blood of this F_1 bull from a Holstein-Friesian × Ayrshire cross. The white markings and high cut hind legs do much to accentuate the Ayrshire appearance.

A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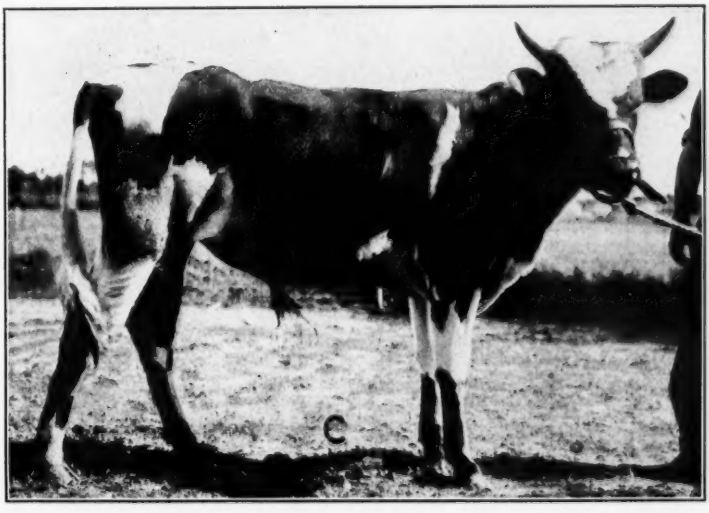
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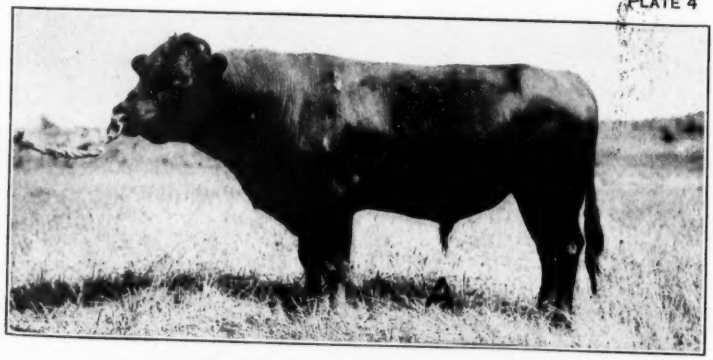
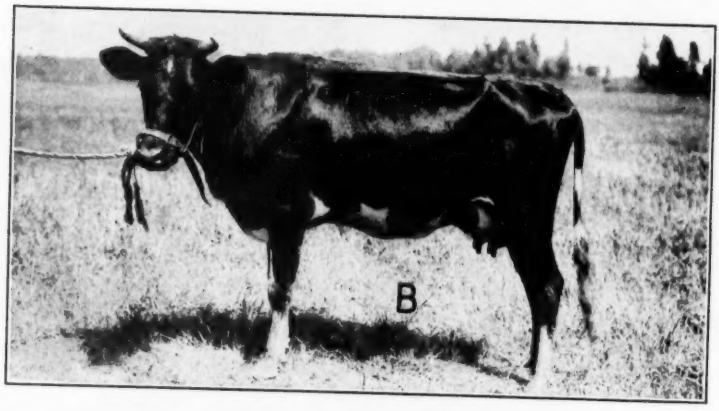
PLATE 4





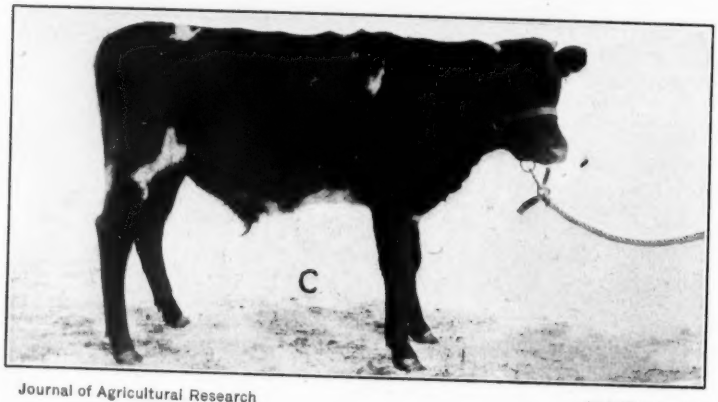


PLATE 4

A.—Crossbred 9: This crossbred is essentially of the beef type. The Holstein-Friesian blood could scarcely be noticed except, perhaps, in the slightly high cut hind quarters. The characteristic scurs of the Angus crossbred male are easily noted.

B.—Crossbred 11: This animal is distinctly an intermediate between the Holstein-Friesian and the Jersey. The dish of the face and the thin nose and rump show plainly the Jersey. The parallel lines of the back and belly show the Holstein-Friesian influence.

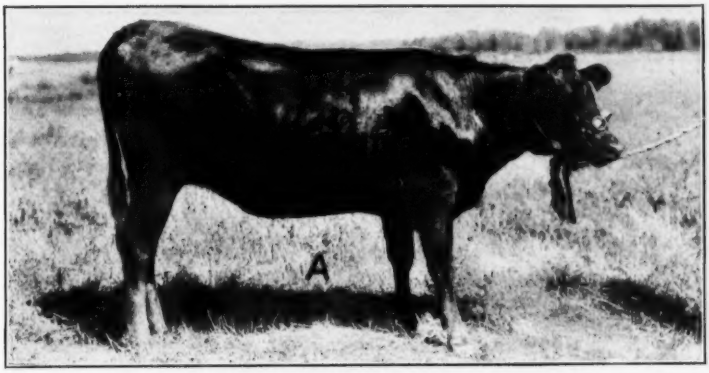
C.—Crossbred 14: Another Holstein-Friesian-Jersey cross; this time a bull. The picture shows that the intermediate type is transmitted to the male as well as to the female.

PLATE 5

A.—Crossbred 15: This F_1 female out of a Jersey × Aberdeen-Angus cross shows the characteristic polled condition of the females of the Aberdeen-Angus crosses. The body type is that of the well-fleshed Jersey rather than the Aberdeen-Angus.

B.—Crossbred 19: A typical freemartin born twin with No. 18. The polled condition with loose bursas under the skin is interesting. The Angus blood is much more in evidence than the Jersey, as seen especially in the rounded condition of the body and heavy fore quarters.

C.—Crossbred 23: A Holstein-Friesian × Jersey bull, showing white hind feet and switch. He comes from a cross the male parent of which has the marks and the female of which is solid color. The pedigree of this female shows that she probably carries these marks.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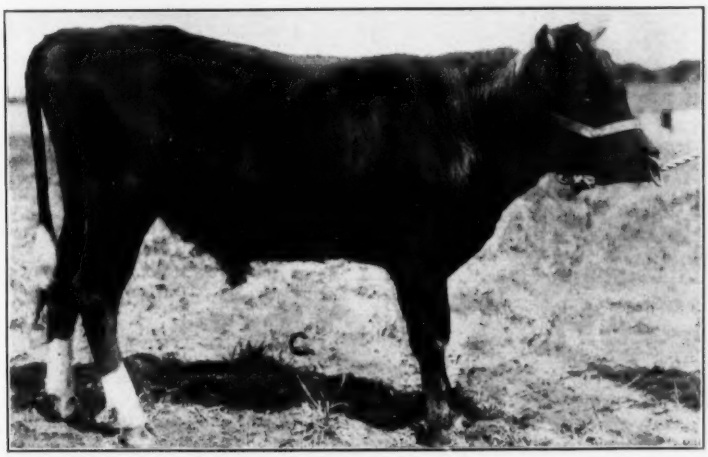
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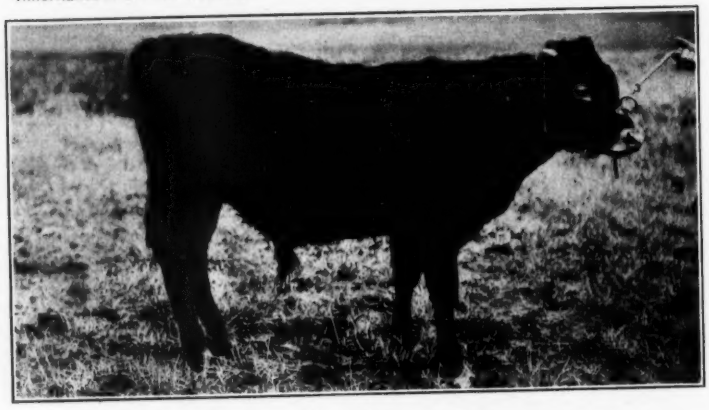

B

PLATE 6

A.—Crossbred 38: This F_2 bull comes from the cross of a black F_1 bull Aberdeen-Angus-Guernsey × Guernsey. He is solid orange in color, carries horns, the light eye ring, and muzzle color of the Guernsey breed. The conformation resembles the Guernsey, especially in the region of the loin, chine, and tail set.

B.—Crossbred 21: This bull is the progeny of Kayan (Aberdeen-Angus clean-polled bull) mated with Dot Alaska (Ayrshire). Note the heavy, solidly attached horns grown while only a year and four months old. The Aberdeen-Angus blood is plainly seen in the heavy, beefy conformation of this bull. The other horned animal had horns even longer than these at this age.